Compressed Air Magazine

Vol. XXX, No. IV London New York Paris 35 Cents a Copy

APRIL, 1925

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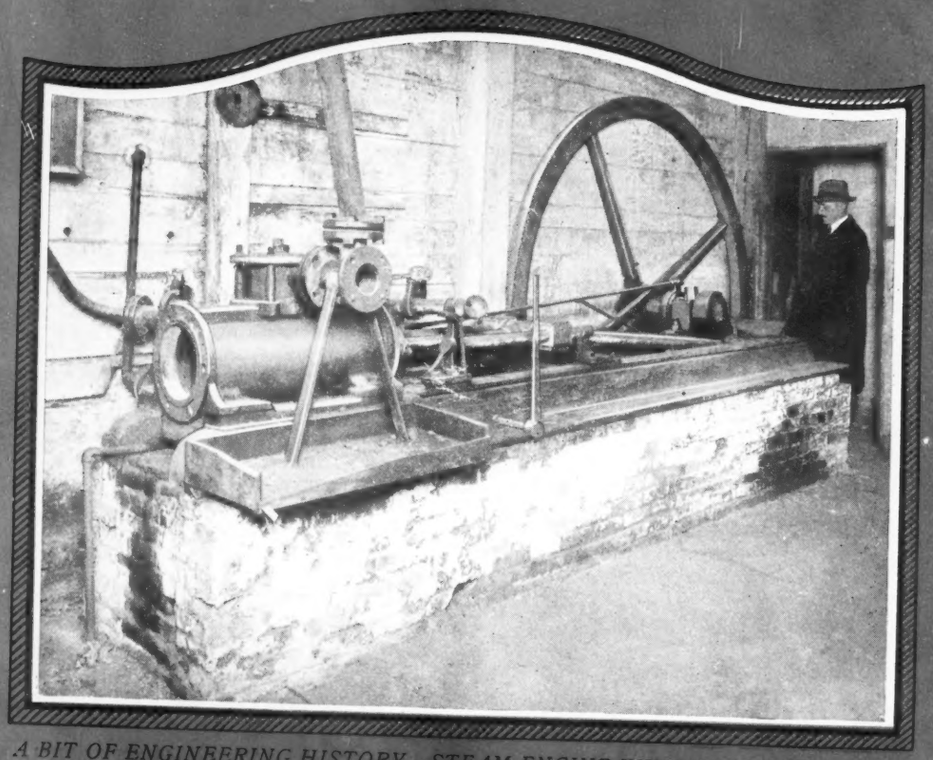

A BIT OF ENGINEERING HISTORY. STEAM ENGINE WHICH USED TO DRIVE THE BLOWERS IN A PENNSYLVANIA BLAST FURNACE BUILT IN 1742

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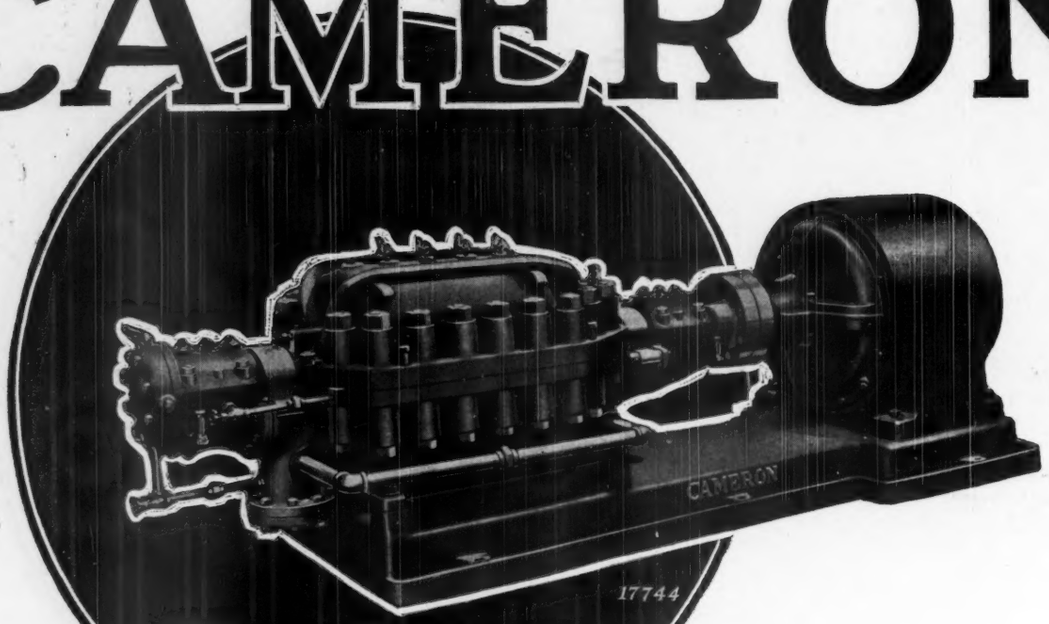
CAMERON



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VOL. XXX, NO. IV

APRIL, 1925

Building A Difficult Trail in the Grand Canyon of the Colorado

Air-Driven Rock Drills and a Portable Compressor Packed to the Job on Mule Back Make Rapid Construction Possible

By M. R. TILLOTSON*

NEARLY 5,000 miles of trails—mostly for the convenience of tourists—were constructed last year within or adjacent to our 147 national forest reserves.

In some instances this work was in no wise difficult, but in other cases the roadbuilders had to contend with natural obstacles that made advance hard and even hazardous. Such was the state of affairs that confronted the trailbuilders in a certain section of the Grand Canyon of the Colorado.

The present article tells how compressed air and air-driven rock drills have been used in successfully attacking the rocky faces of sheer cliffs at points which involved taking the equipment apart and carrying it to the job on the backs of sure-footed pack animals.

WHETHER the Kaibab trail crosses Bright Angel Creek or Bright Angel Creek crosses the Kaibab trail has long been a moot question among old-timers of the Grand Canyon country. Leaving them to argue the point, the fact remains that in following the trail, as it has been used for years, the traveler going through the box canyon of Bright Angel Creek must, in a distance of 3.67 miles, ford the stream a total of 62 times.

John Wesley Powell, who was the first to make the trip through the Grand Canyon of the Colorado River with his party in 1869, gave to this clear sparkling creek the name of Bright Angel in contrast to a muddy stream, encountered in the upper stretches of the canyon, which he had previously christened The Dirty Devil. To the tourist or packer, who from choice or necessity travels the trail up Bright Angel Creek, the qualities of the stream and the canyon in which it flows are anything but angelic in spite of the fact that the grandeur and ruggedness of the scenery are exceptional even in a region noted for deep canyons, sheer cliffs, and brilliantly colored strata.

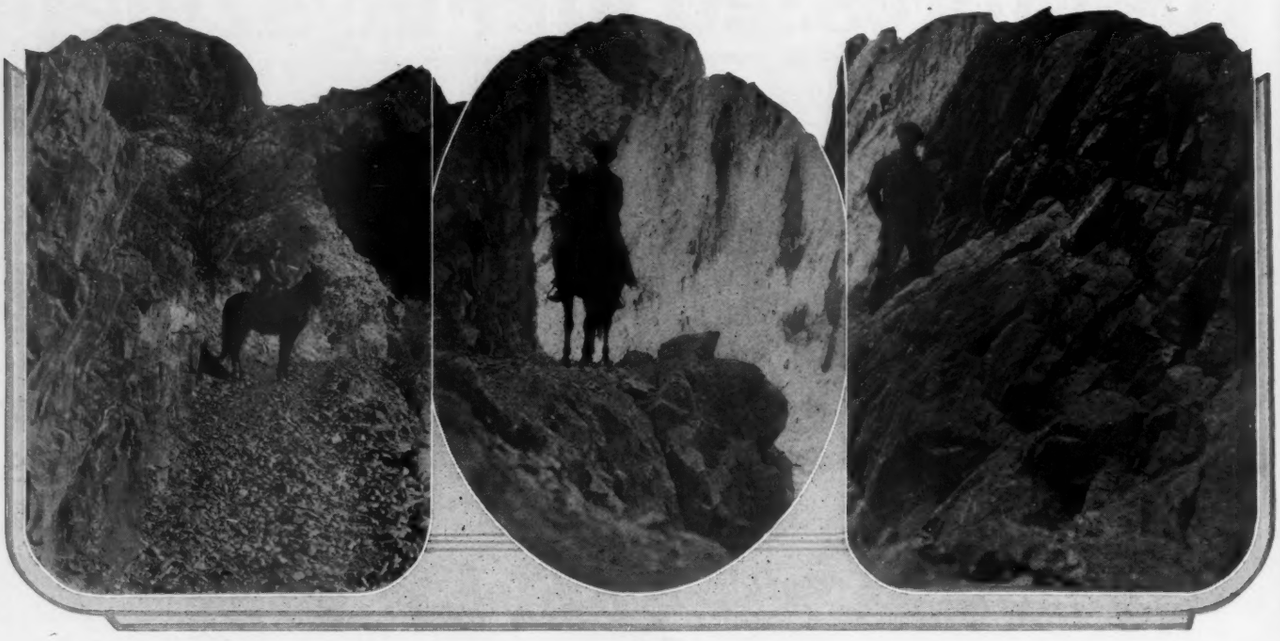
Fed by springs and melting snow on the north rim of the Grand Canyon, Bright Angel Creek flows in a southwesterly direction from its source, the elevation of which is about 8,000 feet, to mingle its crystal waters with those of the muddy Colorado at an elevation of 2,500 feet. Minimum low-water flow is approximately 25 cubic feet per second, but spring thaws and summer rains frequently cause floods that bring the flow to many times the volume at low water. Flowing as the creek does for long stretches through a box canyon, whose sheer vertical walls tower hundreds of feet directly above the stream bed, the sudden freshets for which the stream is notorious are a constant source of danger to the traveler who may, without warning, be caught in the canyon by floods from which there is no escape.

The turbulent stream is constantly rolling huge boulders down its bed, making the crossings at the many fords exceedingly dangerous for both horse and rider. Even disregarding the fact that the trip is extremely hard on pack and saddle stock and hazardous because of the loose and constantly shifting rocks in the many fords, continual splashing—belly deep to a horse—through the cold waters will almost completely drench a rider by the time he has negotiated the 62 crossings in the box canyon proper. After reaching the upper end of the so-called "box" he still has some 14.5 miles with 7 more fords to travel to gain the north rim. In this stretch of the canyon, although it is extremely rugged and precipitous, are not encountered the sheer vertical granite walls extending to the water's edge that are characteristic of the lower portion of the canyon. Furthermore, the remaining fords are nearer the source of the stream where it is neither so deep nor so wide and consequently do not constitute a real obstacle.

By its erosive action the Colorado River has formed, for a distance of 217 miles, "the most sublime of all earthly spectacles"; and the trail in question is the only maintained trans-canyon trail connecting the El Tovar Hotel, at Grand Canyon village, on the south rim with the Kaibab forest and that portion of Grand Canyon National Park which includes the north rim of the canyon. Near the mouth of Bright Angel Creek is Phantom Ranch, a year-round resort owned and operated by Fred Harvey, which is visited each year by increasing hundreds of tourists from both the south and the north rims. Six miles above Phantom Ranch is a small tributary to Bright Angel Creek known as Ribbon Creek. This stream, to reach the level of Bright Angel, plunges over a cliff 149 feet high and forms a most beautiful and spectacular waterfall named Altar Falls from the huge mound or altar of travertine, 42 feet high, which has been built up at the base of the falls by the lime-impregnated waters. These and many other features make the Kaibab trail one of the most popular and extensively used in the entire canyon.

Having in mind the increasing use made of this trail each year and the dangers and hardships encountered along the way, the superintendent of Grand Canyon National Park gave instructions for an engineering investigation with a view to altering the route. Several unsuccessful attempts were made to find a feasible route for a trail that would not have to enter the box canyon but which would lead to the north rim of the Grand Canyon by way of the Tonto Plateau, some 1,500 feet above the Colorado River. The excessive grades by which this plateau is reached, the necessity for materially increasing the length of the trail in heading many side canyons, and the fact that there would be no protection along the desert from the blazing heat of the sun, led to the conclusion to follow a water grade through

*Park Engineer, Grand Canyon National Park, Arizona.



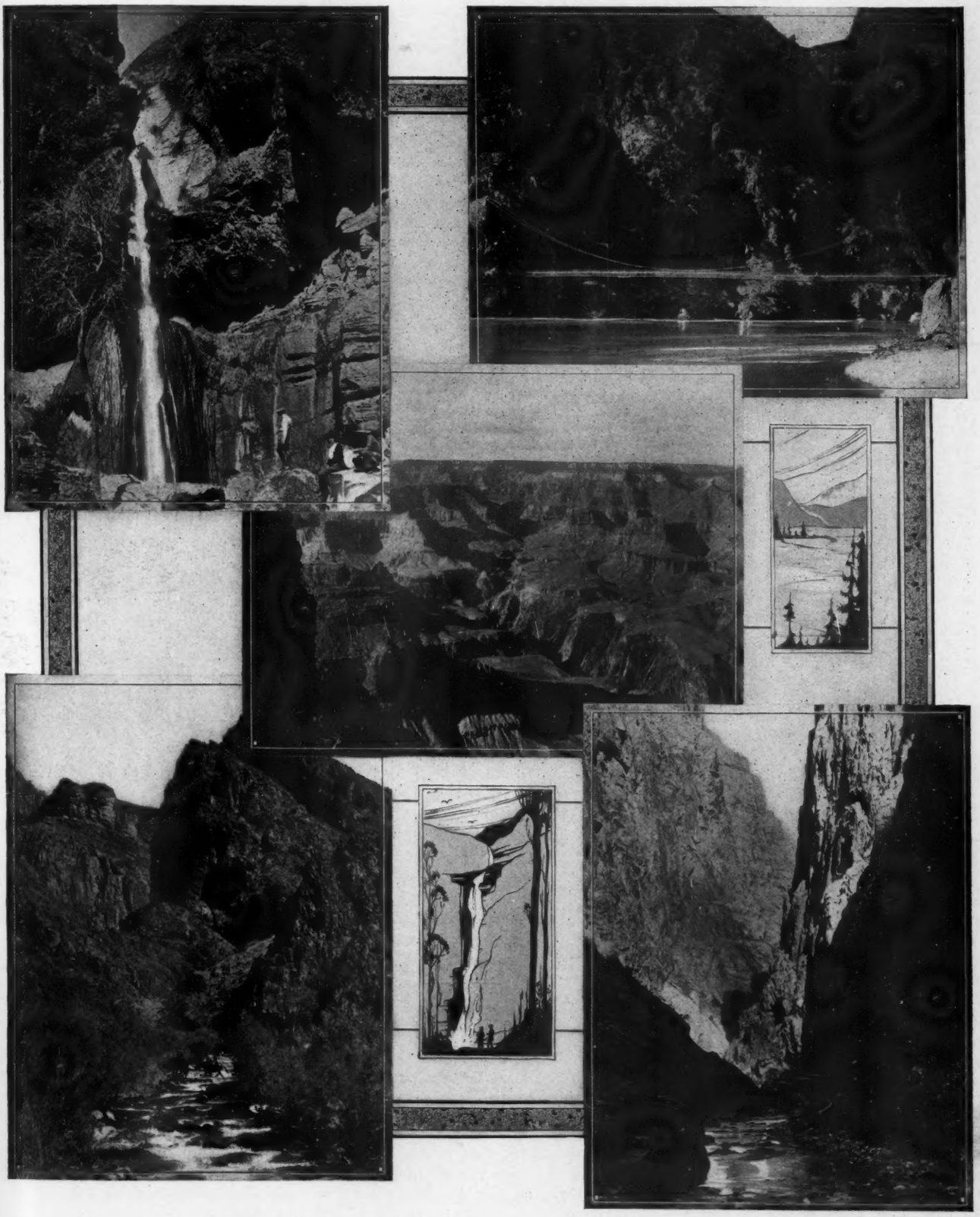
Left and center—Parts of completed trail where it was blasted out of the solid cliff. Right—On the line of the trail before rock was removed.

the box. A careful and detailed survey of Bright Angel Creek canyon was then made, with the result that it was decided to construct a new trail through the box canyon along a selected route which would involve 6 instead of the original 62 crossings of the stream—the 6 crossings to be made by means of permanent bridges of the steel-beam type with concrete floor, bituminous wearing surface, and woven-wire guard rails.

The bridge sites chosen involved spans varying from 16 to 25 feet with a corresponding variance in the size, the number, and the spacing of the channel bars and I beams to be used. A very important factor influencing the design of these structures was that of transportation. All materials for these bridges had to be packed by mule train a distance of from 12 to 15 miles, under which conditions the weight and the length of any single member had to be limited to 250 pounds and to 9 feet, respectively.

No attempt was made to estimate the actual yardage of rock to be removed in constructing the new trail for, in addition to that which had to be blasted out for the tread of the trail, there was an immense volume of overhanging ledge and loose projecting rock, directly above the trail route, that had to be shot away to avoid the possibility of danger from falling rock after the opening of the trail to traffic. It was determined, however, that in the 3.67 miles of construction through the box canyon alone there was approximately 5,955 linear feet of work in solid rock. Some 35 per cent. of this involved the cutting of a bench or shelf in the face of solid cliffs rising perpendicularly from the water's edge. The remaining 65 per cent. of the 3.67 miles involved short stretches of work in open flats, with many large boulders to be removed, in rock slides, and in loose rock and dirt banks. Throughout the entire distance the rock is a particularly hard and

Left—"Jackhamer" man on the ledge. Center—Assembled portable supplying air for the rock drills. Right—Trail Foreman Haden Church handling a "Jackhamer."



These picturesque wonders of the Grand Canyon are being made more accessible to the tourist by means of the portable compressor. Taking them in order, they are:

Beautiful Altar Falls on Ribbon Creek.
Suspension bridge over Colorado River on Kaibab trail.
Grand Canyon of the Colorado viewed from Maricopa Point.
Fording Bright Angel Creek at upper end of box canyon.
Box canyon of Bright Angel Creek at mouth of Phantom Creek.

seamy red granite, difficult to drill, destructive to drill bits, and very uncertain as to how it will break in shooting.

With the great amount of rock work to be done and the character of the rock encountered it was readily apparent that this was no job for hand drilling. Unless there could be obtained adequate air-power machinery it was felt that the project would have to "die a'bornin." And in this connection the adequacy of the equipment, in view of the transportation difficulties involved, depended almost entirely upon the extent to which it was portable.

Since the earliest days, mountain trails have been a most important factor in the development and the opening of the whole of the western country. Many trails, still in use, were in existence before the coming of the white man. The old Indian trails frequently were located with regard to their strategic value, following, wherever possible, the higher and more open ridges so that a continuous lookout might be had to guard against the approach of enemies. As trail construction began with the early white settlers and miners, the theory applied by them in deciding upon a route was ofttimes that axiom of geometry that "a straight line is the shortest distance between two points." In either case, many of the old existing trails were run with a supreme disregard of gradient, drainage, and snow conditions. Even after the location and the construction of trails began to receive proper engineering attention the original laborious hand methods of trail building were still followed for the reason that, by their very nature, trails are located in the more rugged and inaccessible mountain regions. Had they been run in more accessible places they would not have been built as trails but rather as roads. It has always been this feature of inaccessibility which, seemingly, has precluded the use of power machinery in trail construction. The decision, therefore, to use compressed air for drilling in connection with this project marked somewhat of an innovation in trail-building history.

Photo. Kolb Brothers.

Pack train, loaded with compressor parts, at head of Bright Angel trail.

There still remained the problem of finding the particular machine that would be best adapted to the conditions encountered on this job—conditions that involved transportation alone. The machine had to be capable of operating a light "Jackhamer," which meant a delivery of not less than 60 cubic feet of free air per minute at 100 pounds pressure. It had to be self-contained, easy to dismantle, simple to reassemble, and, when dismantled—and herein lay the stumbling block, no single section was to weigh more than 250 pounds, preferably not more than 225 pounds, because the machine had to be packed by muleback from the railroad on the south rim to the bottom of the Grand Canyon. The Bright Angel trail, over which the packing had to be done, has many sharp switchbacks and is extremely steep, the grades averaging from 25 to 30 per cent. and reaching a maximum of 36 per cent. In a distance of three miles this trail makes its first drop of some 3,000 feet in elevation. Then, after six miles across a comparatively level plateau, there is another drop of 1,500 feet in two miles toward the Colorado River. This stream is crossed on a suspension bridge, 420 feet long, which is just wide enough for a loaded pack animal. Another easy mile on water grade down the river and up the lower stretches of Bright Angel Creek and the starting point for construction work is reached.

Photo. Kolb Brothers.

Party starting down Bright Angel trail leading to the Colorado River.

With these points in mind, specifications were drawn up and submitted to six manufacturers of air-compressing equipment. An analysis of the replies received indicated that but one of them could, in every respect, meet the conditions. An order was therefore placed with the Ingersoll-Rand Company for one of their new Type Twenty 4¼x4-inch portable compressors, together with a BAR "Jackhamer" and the necessary air hose and accessories. Prompt delivery was had from the Los Angeles branch, and the machine was at once set up and given a trial run.

As soon as the preliminary tests were finished the compressor was completely dismantled and made ready for packing. In order properly to

balance the loads and to give each mule the weight he could handle to the best advantage all the larger parts of the machine as well as the assembled loads were carefully weighed. The two heaviest pieces were the frame, which weighed 205 pounds, and the motor block, which weighed 189 pounds including cam shaft and timing gears. The total weight of the machine ready to operate, but without fuel and water and the top and side covers, is about 1,250 pounds.

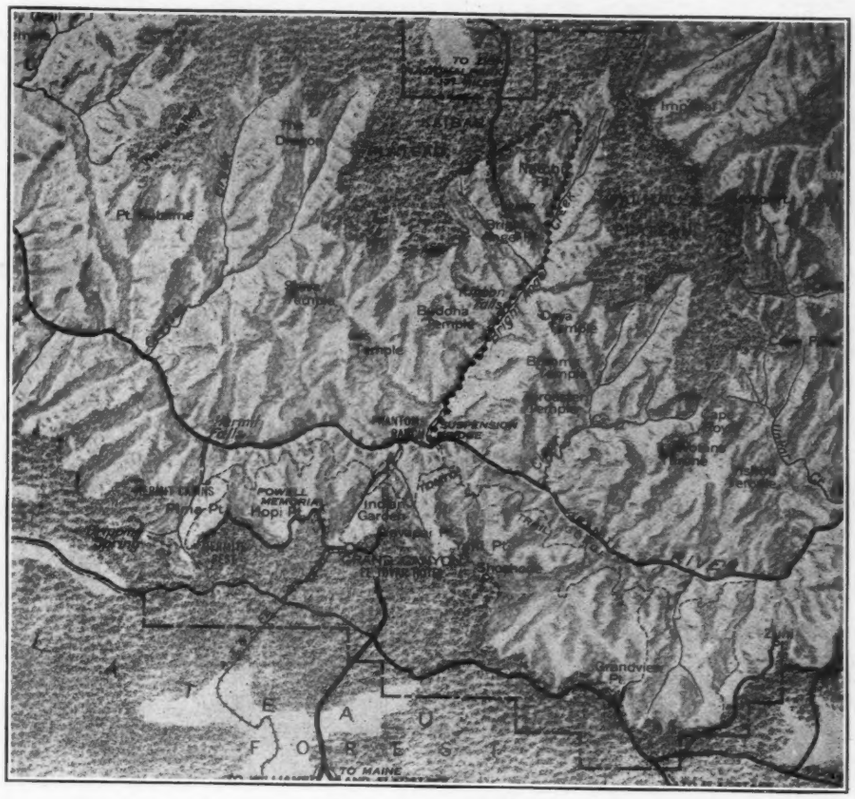
While the weight of neither of the two heaviest pieces was an excessive load for a good mule even for the trail to be followed, both pieces were, of course, top packs—that is, it was impossible to distribute the gross weight of each so that it would hang low on the mule's sides where it could be carried to the best advantage. The frame, 21 inches wide by 75 inches long, was lashed by means of the familiar "diamond hitch" on top of empty "kyacks" or wooden pack boxes which were, in turn, fastened by means of sling ropes to the pack saddle. A pack train of twelve mules easily handled the packing. On the entire job there was not encountered what might be called even a minor difficulty in transporting the air compressor, thus demonstrating that this particular type is truly portable under the most difficult conditions. Any packer experienced in moving freight by pack train can readily handle such a job. Drill steel was packed on lumber bunks, the type of pack saddle used in transporting lumber by mule back. Two ordinary Ford gas tanks, set in wooden slings made to fit them, proved excellent containers for packing gasoline. The T.N.T. used for blasting was packed in cement sacks—three 50-pound sacks making a mule load.

The pack train reached the trail camp late one evening. Work of assembling was started the next morning by a mechanic and a helper, neither of whom had had any previous experience with air compressors. In spite of this fact and the handicap under which they worked in the open—lacking the equipment and the conveniences that would have been available had they been setting up the unit in a shop—the machine was in operation by the next afternoon. Barring a few days' delay caused by a broken valve seat, the compressor has been building trail rapidly, steadily, and efficiently all winter.

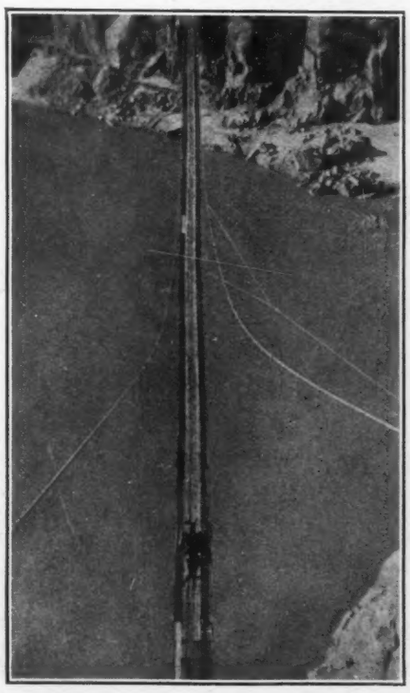
The granite formation in which drilling is being done varies considerably in hardness. In some sections the best that could be done with a ⅞-inch hexagonal drill steel was at the rate of from 8 to 10 inches per hour, while in others drilling was done at an average rate of 82 inches per hour. In the hardest sections of this granite formation it is almost out of the question to drill a hole in any length of time by the old method of double or of single jacking. Gasoline consumption averaged from ½ to ⅝ gallons per hour, steady running.

The trail is being constructed with a minimum tread of 48 inches, the average being from 54 to 60 inches. As the gage of the truck on which the compressor is mounted is 46 inches there is ample room to move the machine along as the work progresses. Although a block and tackle was provided for moving the machine it was found that the compressor could, without serious difficulty, be pulled by hand. Occasionally, when the engineer or a visitor is in camp with a saddle horse the efforts of the crew in moving the machine are supplemented by a rope from the saddle horn.

The crew handling this job consists of twelve men, under the very able foremanship of Mr. Haden Church, and is made up of one subforeman, one compressor man, two powder men, one rock man, one blacksmith, one cook, and five muckers. Excellent progress is being made; and the results accomplished have demonstrated clearly the feasibility of trail construction with the use of modern air-power equipment even under conditions most unfavorable to the transportation of such machinery.



Dotted line indicates the course followed by the new trail.



Bird's-eye view of suspension bridge over the Colorado River showing a laden pack mule crossing the span.

GALVANIZED-IRON SHEETS FOR LOCUST BARRIERS

ARGENTINA has developed an unusual use for galvanized-iron sheets, and during the past year the government of that country has been in the market for about 40,000 tons to be employed for the purpose of fighting locusts. The agricultural districts of Argentina are often overrun by great swarms of locusts which devastate the land traversed by them unless drastic measures are taken for their extermination.

The government has conceived the scheme of keeping on hand supplies of galvanized-iron sheets and of issuing them to farmers in the affected territory. Close, tight-fitting fences are built of the sheets in such a manner that insects cannot crawl through or around them. The barriers are put around the areas where the locusts have bred; and the young insects, which have not developed wings, are thus halted in large numbers. They may then be destroyed by fire.

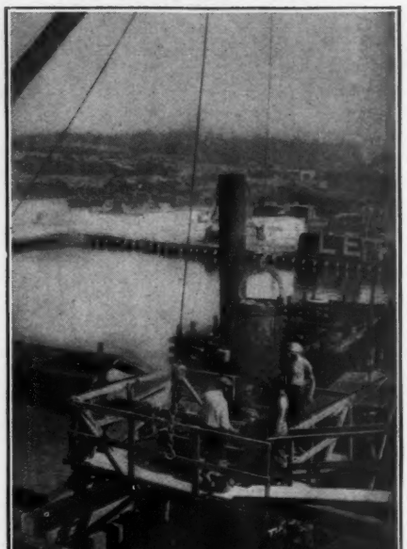
Progress on Victory Bridge Over Raritan River

SOME months ago we published a brief article having to do with the bridge across the Raritan River at Perth Amboy, New Jersey, confining ourselves principally to a description of the main caisson which is to have its final resting place on bed rock at an exceptional depth below the surface of the water.

The work has been going forward steadily, and we are now enabled to tell more about this engineering task, thanks to a recent article printed in our informative contemporary, *Successful Methods*. The following information is abstracted from that publication. The contract for the new bridge was let on December 11, 1923, to the Stillman-Delehanty-Ferris Company of Jersey City, and work began almost immediately. The cost of the bridge will be $3,702,921, and the contract provides that it be finished in 30 months. The work has progressed to such an extent that it probably will be finished within the contract time and ready for traffic in the spring of 1926. The general contractors are building all but the river piers, which are being constructed by the Foundation Company.

The bridge, including approaches, is 8,500 feet in length. Of this, 1,077 feet consists of reinforced-concrete viaduct, and 1,536 feet of steel spans including 16 plate girder spans and one draw span 360 feet in length. The approaches at each end, measuring in all about 5,536 feet, consist of earth fills. The bridge structure will rest on 55 piers. Of these, Piers 1 to 9 inclusive and 25 to 55 inclusive are in the meadows at each side. Piers 10 to 28 inclusive are in the river, and all except Piers 13, 14 and 15, which go to rock, are constructed on piles. Approximately 300,000 linear feet of piles have been driven.

The central piers, constructed by the Foundation Company, including the pivot pier on which the draw span will rest, have been built by the air caisson method. The caisson for one of the rest piers established a new record in American bridge construction, as it is being sunk 115 feet, a greater depth than that of any other bridge pier in the United States. The work being done by the Foundation Company consists of the construction of the six river piers. Nos. 13, 14 and 15 are built by the pneumatic caisson method. and Nos. 11, 12, and 16 with pile foundations in open cofferdam.



Courtesy, Successful Methods.

One of the air locks on the great caisson which is being sunk to an exceptional depth.

All pneumatic caissons are carried to rock. The caissons used are of the most modern type and equipped with the best and latest devices for handling men and materials into and out of the working chamber. The work of the Foundation Company began March 1, 1924, and will be completed early in 1925.

© Aero Service Corporation.

Activities at the site of the Victory Bridge, across the Raritan River, viewed from aloft.

The work is being carried on under the general supervision of Major W. G. Sloan, State Highway Engineer of New Jersey. The New Jersey legislature, by special act, has designated the new structure the Victory Bridge.

DETERMINING THE THERMAL EXPANSION OF STONE

THE determination of the thermal expansion of stone, that is, the amount a stone changes in size with change in temperature, has received very little attention in this country. Furthermore, an examination of the available data on the subject reveals that the few determinations which have been made were generally based on a limited number of observations and are, therefore, rather misleading. The values most frequently cited in textbooks and handbooks are based on coëfficients obtained by measuring the length of specimens at normal temperature—the assumption being that the material expands at a uniform rate at all intermediate temperatures. Researches conducted at the United States Bureau of Standards, in which frequent length measurements of limestone and marble specimens were made as their temperatures were raised, indicate that these old assumptions are far from correct.

For slight increases in temperature above the normal the expansion is very small, but as the temperature rises the rate of expansion grows rapidly. At 212°F. the average expansion of marble is about the same as that of steel, but at 392°F. the rate is approximately doubled. For temperatures a few degrees above the normal the expansion is only a fractional part of that of steel. These peculiarities are of particular interest wherever stone is used in connection with other materials, as is usually the case in the construction of buildings.

Marble, especially, shows other peculiarities under temperature changes. It expands on heating; but when cooled to the original temperature it does not shrink to its original dimensions. In other words, it retains a part of the expansion as a permanent growth. Specimens measured under low temperatures have been found to expand when cooled below the normal, which is also contrary to the usual conception. These properties probably account for the peculiar instances of warping which have been noted in marble headstones in cemeteries.

Driving First Tunnel Through the Continental Divide

Details About the Methods Employed at the West Portal in Drilling, Blasting, Mucking, and Timbering

By ROBERT G. SKERRETT

PART III

OPERATIONS at the west portal have emphasized the wisdom shown by the Commission in its choice of technical executives and in its award of the tunnel-driving contract to men thoroughly versed in doing work of this character in the face of great natural difficulties.

While the contractor is called upon to have the Moffat Tunnel finished within a period of 46 months from the signing of the contract—that is, by July 19, 1927, still everything is being done by Hitchcock & Tinkler, Inc., to do still better and to have the tunnel holed through not later than July 4, 1926, when Colorado will celebrate the golden anniversary of her admission to statehood.

With this end in view, the contractor began excavating at the west portal within a few days after the contract was awarded; and by the end of September, 1923, the water tunnel had been advanced 32 feet into the mountainside.

DURING the month of February an average daily advance of a little more than 21½ feet was maintained in driving the water tunnel at the west portal; and in the course of only 28 days that water tunnel was pushed forward a total of 600 feet—outstripping the best previous performance there.

On March 1, the status of the whole undertaking was as follows:

	East Portal	West Portal
Water tunnel	8,137 ft.	6,767 ft.
Main headings	8,112 ft.	6,238 ft.
Crosscuts	315 ft.	315 ft.
Railroad tunnel, full size	4,890 ft.	1,072 ft.

To effect this, it was necessary to clear away the open-cut approach to this auxiliary tunnel before going underground. By the close of October, the water tunnel had penetrated a distance of 295 feet. That advance was made through rotten rock which gave little if any evidence of improvement as the heading was pushed onward. Therefore, exploratory work was done to ascertain whether conditions might not be more favorable than they seemed to promise.

Accordingly, drilling was done downward from the surface at several points above and along the tunnel line; but even at depths up to 85 feet the drill steels failed to strike rock. In other words, the heavily timbered, sheltering

Left—A winter's day at the west-portal camp. Right—Part of the picturesque valley down which the Fraser River flows. Bottom—Preparing arch segments of the permanent timbering for the railroad tunnel.

slopes adjacent to the tunnel were found to be for the most part composed of glacial drift. From the very start, the contractor has been obliged to timber not only the water tunnel but also the crosscuts and the railroad tunnel except at a few points where short stretches of relatively stable rock have been encountered. Indeed, much of this rock has been so soft that it could have been excavated with pick and shovel. A number of cave-ins have occurred; and some of these have happened while driving the main heading, while timbering, and even after the heavy timbering was in place.

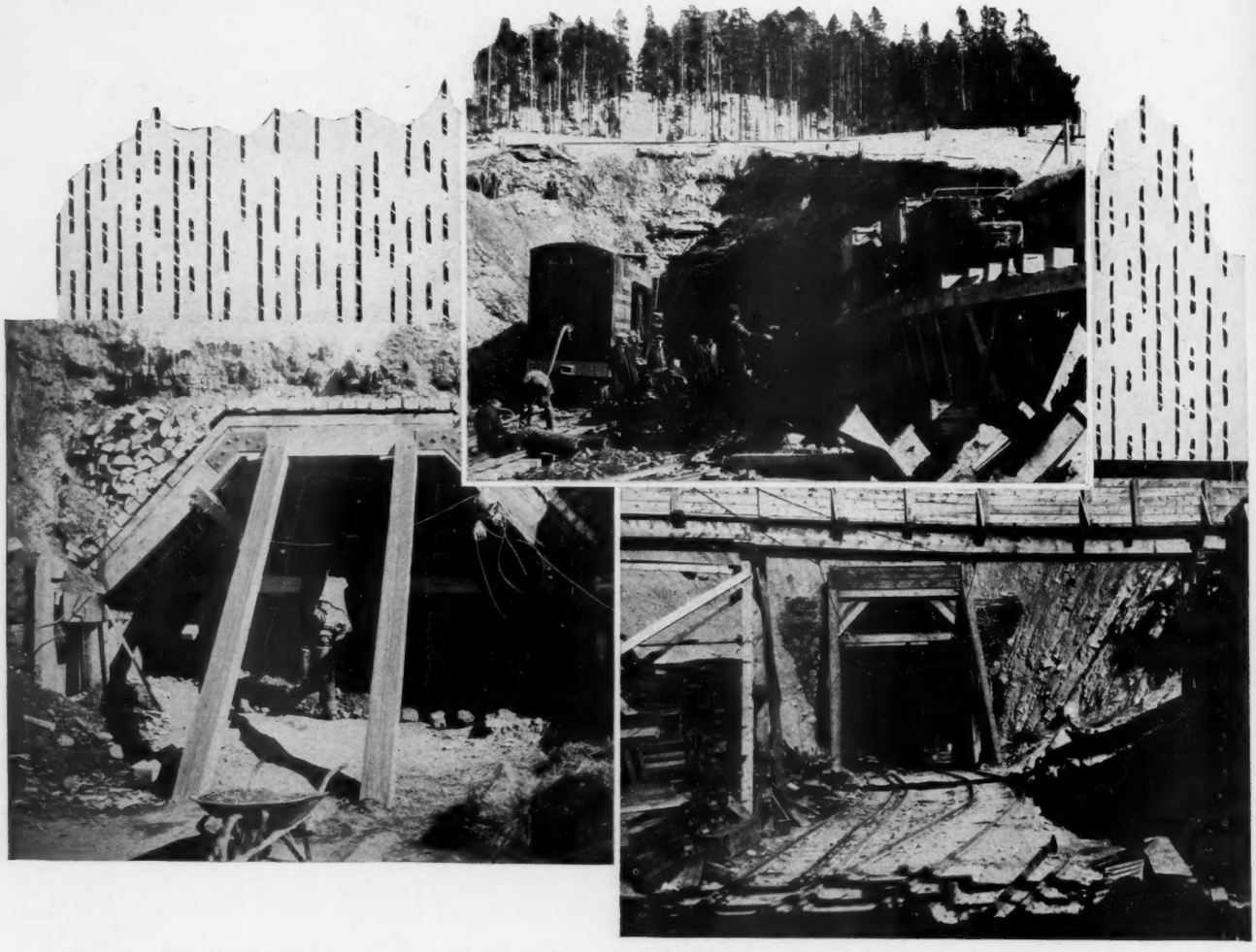
After getting in about 5,600 feet fairly solid rock was met, and the heading was pushed forward substantially 500 feet through this granite without the need of timbering except at one point where a small seam of soft rock was traversed. This state of affairs did not continue, however, because towards the latter part of January just gone the drillers in the main heading came to a blocky fault in the rock at a point 6,000 feet in from the portal, and a serious cave-in resulted. This, in conjunction with previous experiences of a kindred sort, has led the engineers to believe that hard rock with occasional treacherous slips may henceforth be expected until the tunnel reaches the core formation of the mountain. It should be understood that the hard rock so far met on the west side is not as hard and as stable as the rock through which work at the east side has advanced well-nigh from the very beginning of operations there.

As Mr. W. P. Robinson, President of the Moffat Tunnel Commission, pointed out to the writer, the slower advance at the west side is in no wise due to lack of engineering skill or to any fault in design, but entirely attributable to obstacles which Nature has interposed and which no one could have foreseen. Indeed, the contractor has made excellent headway, considering the amount of extra work involved in guarding against and in arresting the inward movement of the rock surrounding the excavations. It is because of the difficulties met and effectually mastered that the work at the west portal is of more than ordinary interest.

Hitchcock & Tinkler, Inc., will, in all likelihood, finish their work some months in advance of the schedule; and they have a monetary inducement to spur them on. According to the terms of the contract, the contractor will receive added compensation at the rate of $1,000 a day for every day—except Sundays and holidays—by which the working period is shortened. Similarly, there is a penalty of $1,000 a day for every day by which completion is delayed through any fault of the contractor. There is no reason to believe that the penalty clause will become operative in fact.

No progress was made at the west portal in driving the main tunnel heading until January of 1924, but during that month the heading of the railroad tunnel was advanced 47 feet into the mountain—the water tunnel at the end of that month having penetrated a total distance of 1,354 feet. The first crosscut was made during February following and at a point approximately 1,500 feet in from the portal. Upon intersecting the line of the main tunnel, this crosscut permitted tunneling operations at two more headings moving in opposite directions. This explains how it was possible to show an aggregate advance of 510 feet in the railroad tunnel by the end of the succeeding March. At that time the neighboring water tunnel had attained a length of 2,187 feet.

Until recently, nearly all the drifting at the headings of the main and the water tunnel has been done with "Jackhamers"; and the character of the drill rounds and the amount of explosive used in charging the holes have varied continually. It has been impracticable to standardize the procedure; and no attempt will be made to go into detail about this phase of the work. Generally speaking, only small



Taken in the sequence of top, left, and right, these pictures illustrate three stages of work at the west portal: The initial excavating of the open-cut approach; the timbering of the portal arch before the removal of the underlying bench; and the completed portal.

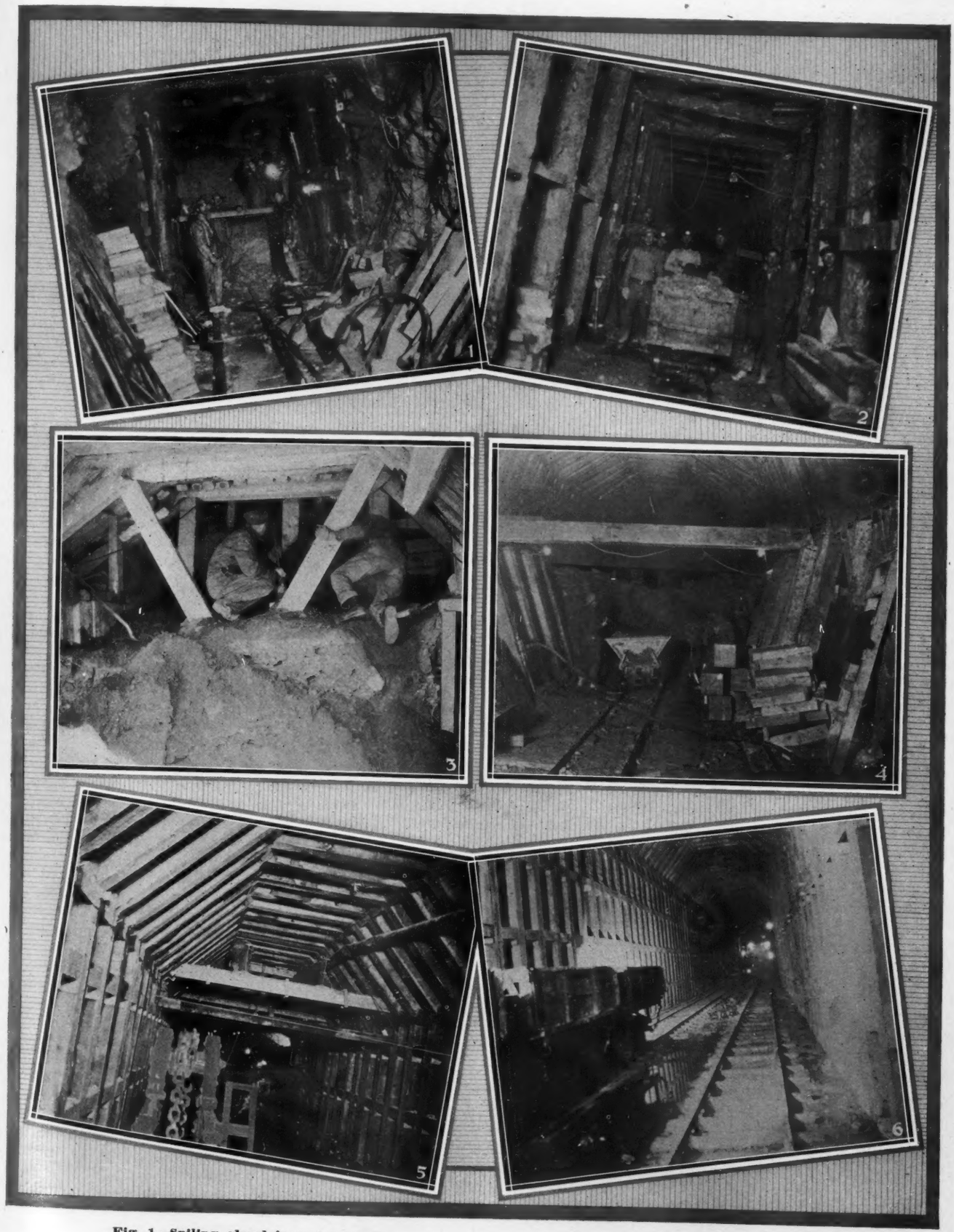


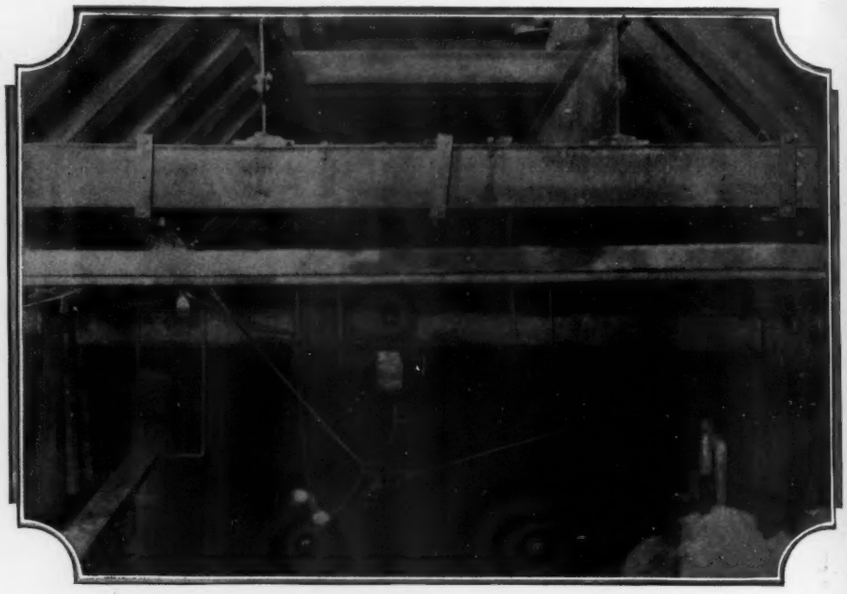
Fig. 1—Spiling ahead in wet ground.
Fig. 2—Close-up of a top heading in the railroad tunnel.
Fig. 3—Spiling in an earth section of the main tunnel.
Fig. 4—Bracing roof segments while excavating the sub-bench.
Fig. 5—Taking out the bench and using needle- eam support the while for the arch timbering.
Fig. 6—Fully lined section of railroad tunnel wi h permanent timbers in position.

charges of 60 per cent. dynamite have been needed to do the blasting in the prevailing soft or rotten rock. The more interesting aspects of this phase of the job are the ways and the means employed in disposing of the muck; and in dealing with this part of the problem it will be plain how much the water tunnel helps in getting rid of the muck.

With the exception of the initial heading of the railroad tunnel—that is, the heading that advanced inward from the portal, muck from all the other headings, both in the water and the railroad tunnel, has been carried out by way of the water tunnel. The crosscut nearest the railroad-tunnel heading is used to facilitate this movement from the main tunnel. The muck trains for this work are hauled by two types of electric locomotives, one type being energized by storage batteries while the other type draws its operating current from a trolley wire. The storage-battery locomotives, of which there are five in service at the west portal, are each capable of exerting a drawbar pull of 1,000 pounds and can make 3½ miles an hour at full speed. The trolley locomotives, of which there are three in use, have a drawbar pull of 3,200 pounds and make 7 miles an hour at full speed. The storage-battery locomotives are charged at a station adjacent to the compressor plant where a simple but ingenious arrangement is provided by which the batteries can be lifted from the locomotives and freshly charged batteries substituted. Both the trolley and the storage-battery locomotives are products of the General Electric Company.

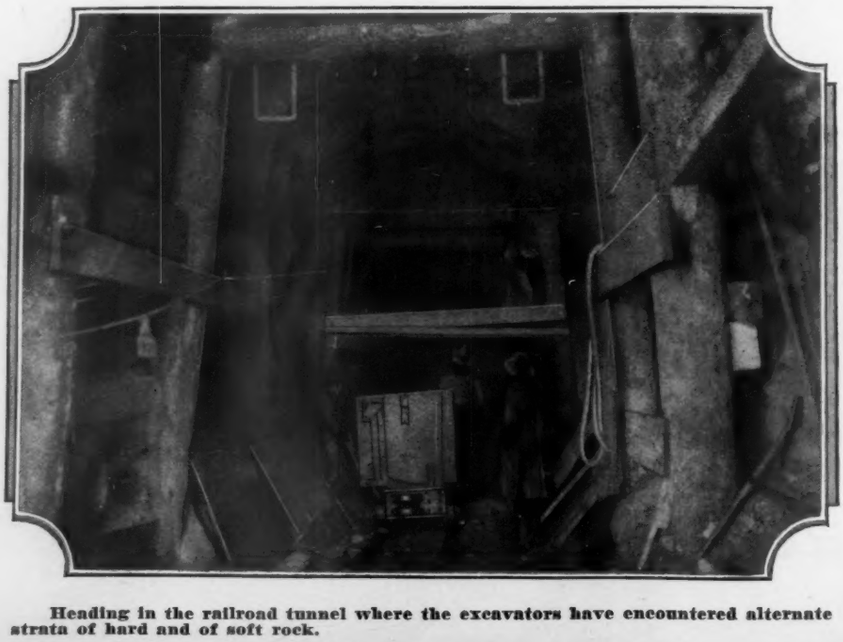
The storage-battery locomotives do the hauling between the headings and the nearest crosscut, and from the crosscut outward through the water tunnel the muck trains are handled by the trolley locomotives. Each trolley locomotive is equipped with a reel large enough to carry 500 feet of power cable which extends the operating range of these locomotives underground and obviates the use of overhead wires at points where the wires might be cut by flying rock during blasting. These cables can be connected with the trolley circuit. The muck is actually removed in Koppel, 1-way, side-dump cars, each having a capacity of 50 cubic feet. There are 55 of these cars on the job at the west portal. It might be mentioned here that much of the muck produced in enlarging the main tunnel is also moved outward by this equipment through the water tunnel. The muck trains travel back and forth over track having a 2-foot gage; and the spoils are dumped at the fill which is being formed across the neighboring valley of the Fraser River. It is over this fill that the connecting line will run which will join the single track of the finished tunnel with the Moffat Railroad where that road now runs a few thousand feet farther down the valley.

Conweigh electrically driven mucking machines do the mucking at the headings in the water and the railroad tunnel. These muckers are rugged affairs and fully capable of handling the rock which is generally broken up into comparatively small pieces by the blasting. There are two of these muckers in service; and before a round is fired the mucker is withdrawn from its heading to a siding where it



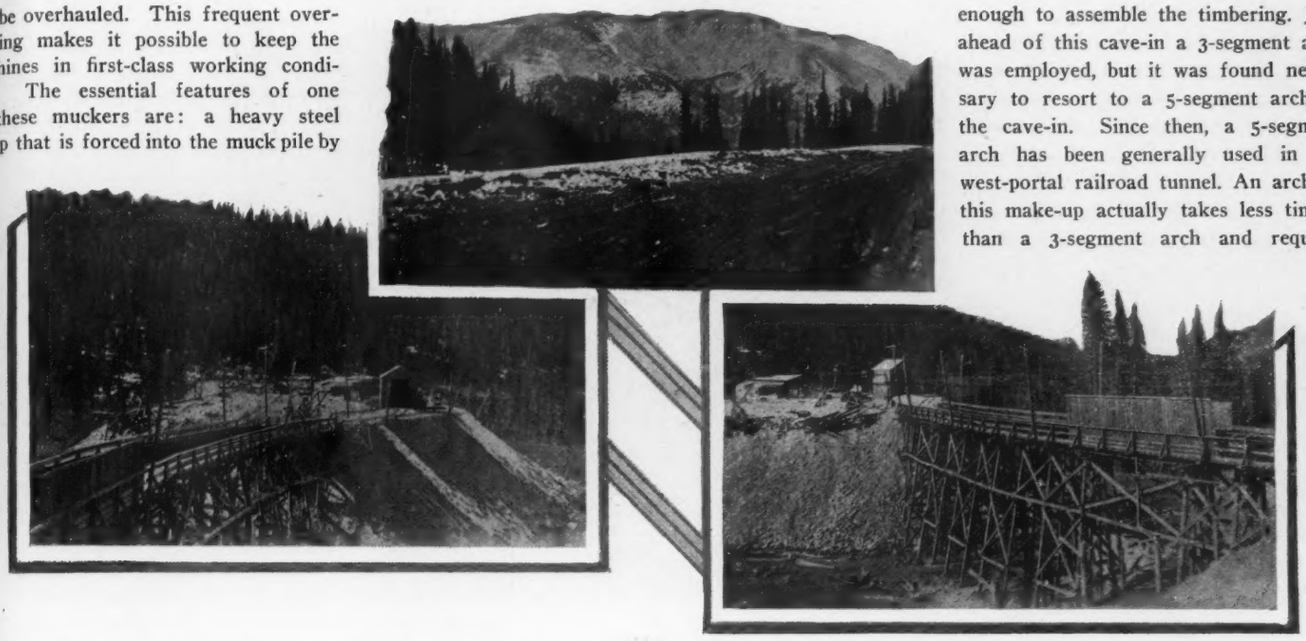
Needle-beam method of supporting roof timbers while taking out the bench.

Water tunnel at Crosscut No. 3. Track at left runs into the crosscut.



Heading in the railroad tunnel where the excavators have encountered alternate strata of hard and of soft rock.

can be overhauled. This frequent overhauling makes it possible to keep the machines in first-class working condition. The essential features of one of these muckers are: a heavy steel scoop that is forced into the muck pile by advancing the machine on the supporting 2-foot gage track; a conveyer belt upon which the rock is dumped by raising the scoop so that the muck will tumble rearward; and a discharge at the back end of the machine which is high enough for a car to be spotted beneath it. Each mucker is actuated by a 50-H.P. motor; and current for this purpose, of 250 volts, is tapped from the line supplying energy to the trolley locomotives. The current is delivered to the mucker by a connecting cable laid on the ground. One of these muckers will fill a car in 90 seconds; but as a general performance approximately 14 of the 50-cubic-foot cars are loaded in the course of an hour.



Top—On the road bound eastward to the crest of Berthoud Pass. The crater-like depression at the top of the snow-clad mountain is a glacial cirque. Bottom—Views of the fill across the Fraser River valley adjacent to the west portal.

Where soft rock is met in the railroad tunnel it has been found expedient to drive the advance heading at the highest practicable point, and thereafter to work outward and downward to grade in widening and in removing the bench. This has necessitated driving the heading onward from the nearest crosscut upon a rising gradient amounting at times to as much as 5 per cent. and then reducing this to 2 per cent. A 5 per cent. grade is the steepest climb the storage-battery locomotives can negotiate when handling muck trains, while a 2 per cent. grade is the maximum one on which the Conweigh muckers can work to advantage. One instance will suffice to explain why both the muckers and the locomotives must occasionally operate under these trying conditions.

Just east of Crosscut No. 2, in the railroad tunnel, the rock caved so badly that it was necessary to carry the top of the heading two feet higher than the maximum height required by the specifications in order to have room enough to assemble the timbering. Just ahead of this cave-in a 3-segment arch was employed, but it was found necessary to resort to a 5-segment arch at the cave-in. Since then, a 5-segment arch has been generally used in the west-portal railroad tunnel. An arch of this make-up actually takes less timber than a 3-segment arch and requires shorter units which can, therefore, be more easily handled.

Before taking up in some detail the manner in which the timbering is done in the railroad tunnel and before describing the subsequent widening out or "winging" process, it is desirable that we mention how the headings are drilled and blasted. Because much of the rock penetrated has been of a blocky and treacherous description—tending to spawl when exposed to either the air or the action of underground water, the method of drilling and blasting has been adapted to meet these conditions. The rock has been easy to shoot with small charges, and for this reason it has been feasible to advance the timbering close to the face of a heading without fear of displacing or damaging the timbering when firing a round.

As originally planned, the intention was to

Railroad-approach fill, near the west portal, by which the tunnel and the existing tracks of the Moffat line will be linked.

Close-up of one of the electrically driven Conweigh mucking machines. The muck is picked up by the scoop at the left and dropped onto the elevator belt at the right, from which the rock falls into dump cars.

shift the drilling gang from one heading to the other while mucking was being done, but this was found impracticable at the west portal owing to the fact that drilling gangs had to be so organized that they could likewise do the timbering at their respective headings. In other words, a drilling gang has been kept continually at each heading. To shorten as far as possible the periods of idleness of the drillers, the ordinary working schedule has been modified by resuming drilling soon after firing a round and before much of the muck has been cleared away.

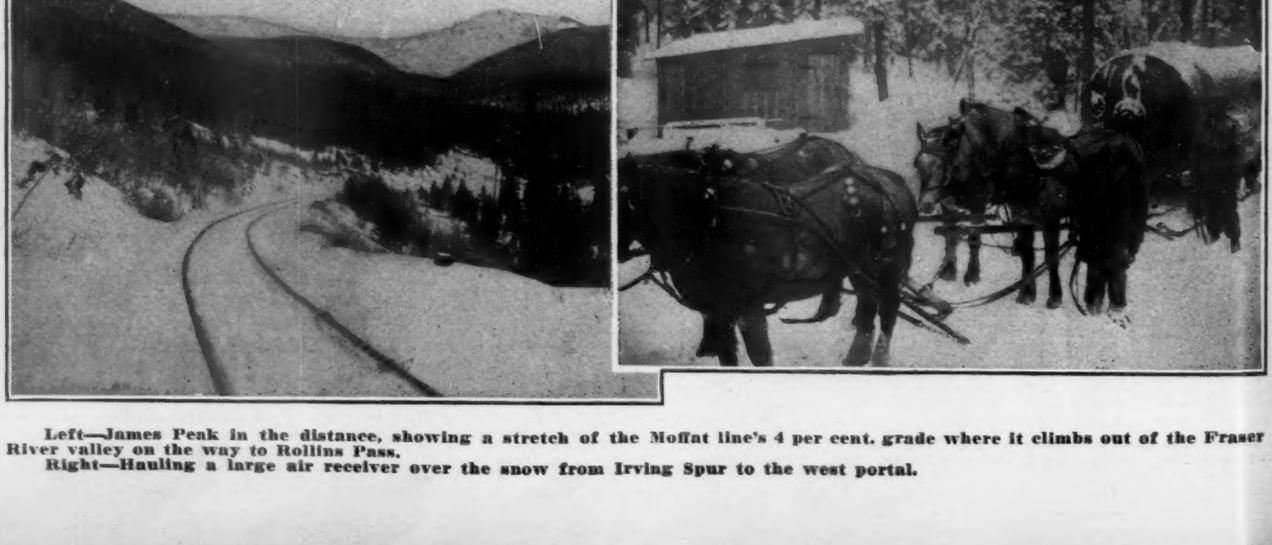
Snowsheds on the west slope at the summit of Rollins Pass. Here it is that the trains on the Moffat Railrond reach an elevation of 11,660 feet above the sea.

To this end, the drillers start work again from the top of the muck pile; and the arrangement of the drill holes is such that the majority of the holes can be drilled as soon as the muck pile has been lowered to about half the height of the heading. Inasmuch as only fourteen or sixteen holes constitute a round in the soft rock, it is feasible to drill from ten to twelve of these while the muck is at the height mentioned. For this purpose, two drills are mounted on a horizontal bar which spans the tunnel at a point about two feet eight inches below the top of the heading. The third row of four holes is drilled downward at an angle of approximately 45 degrees and penetrates to a depth nearly on a level with the bottom line of the heading. The lowermost row of holes is drilled after the muck is cleared away; and the eight holes thus brought close together constitute the cut holes and are fired directly. The eight remaining holes above are fired by delay exploders. The average charge in each hole is five pounds of 60 per cent. dynamite.

The manner of timbering, as previously mentioned, has changed from point to point agreeably to the changing physical conditions of the rock penetrated. The timbering diagrams accompanying this article indicate in a general way how the rock is being supported at different stages of driving and of enlarging the tunnel section. The procedure is in a state of flux, and will continue to vary until the headings at the west end of the undertaking have reached rock of a solid and fairly uniform character, such as has been met in driving the headings inward from the east portals.

The timbering in the advance headings, that is, in the 8x8-foot sections, is made up of bents or sets fashioned from round timber obtained from stands of lodge-pole pine growing on the neighboring mountain slopes. Each bent is composed of two posts and a surmounting cap; and the bents are commonly spaced four feet apart. This timbering supports the spiling which is progressively advanced toward the heading; and the spiling is canted upward from each bent so that the spiling will bear against the roof of the tunnel until the succeeding bent can be put in position beneath it and take over the load—if any. Thus, step by step, the timbering is pushed forward until it is close to the face. Longitudinal struts are interposed between the posts of adjacent sets to stiffen the timbering and to steady it against derangement by subsequent blasting. A modification of this procedure is indicated by No. 1, top heading, in which cantilever needle bars are employed to carry the cap and the spiling nearest the face.

When the round timbers are in place then the top heading is widened out on each wing. This work is not done until the advance heading is 1,000 or more feet farther along. The stages in which this is done are indicated by two of the accompanying diagrams; and after the widening out of the top heading is finished the removal of the underlying bench is next taken in hand. No effort is made to dispose of the bench until the false set of arch timbers has been surmounted by the permanent arch timbers. The removal of the bench is effected in two lifts, each of which is eight feet deep. The lower section of the bench is called the sub-bench. It was at first intended to clear



Left—James Peak in the distance, showing a stretch of the Moffat line's 4 per cent. grade where it climbs out of the Fraser River valley on the way to Rollins Pass.
Right—Hauling a large air receiver over the snow from Irving Spur to the west portal.

Left—Some of the plant buildings and muck cars at the west portal.
Right—The connecting line by which the tunnel track will be linked with the existing 2 per cent. grade of the Denver & Salt Lake Railroad at a point less than a mile away from the west portal.

away the bench from top to bottom at a single operation, but difficulties were encountered in carrying this out. Therefore this procedure was abandoned after the railroad tunnel had penetrated the mountainside only a few hundred feet.

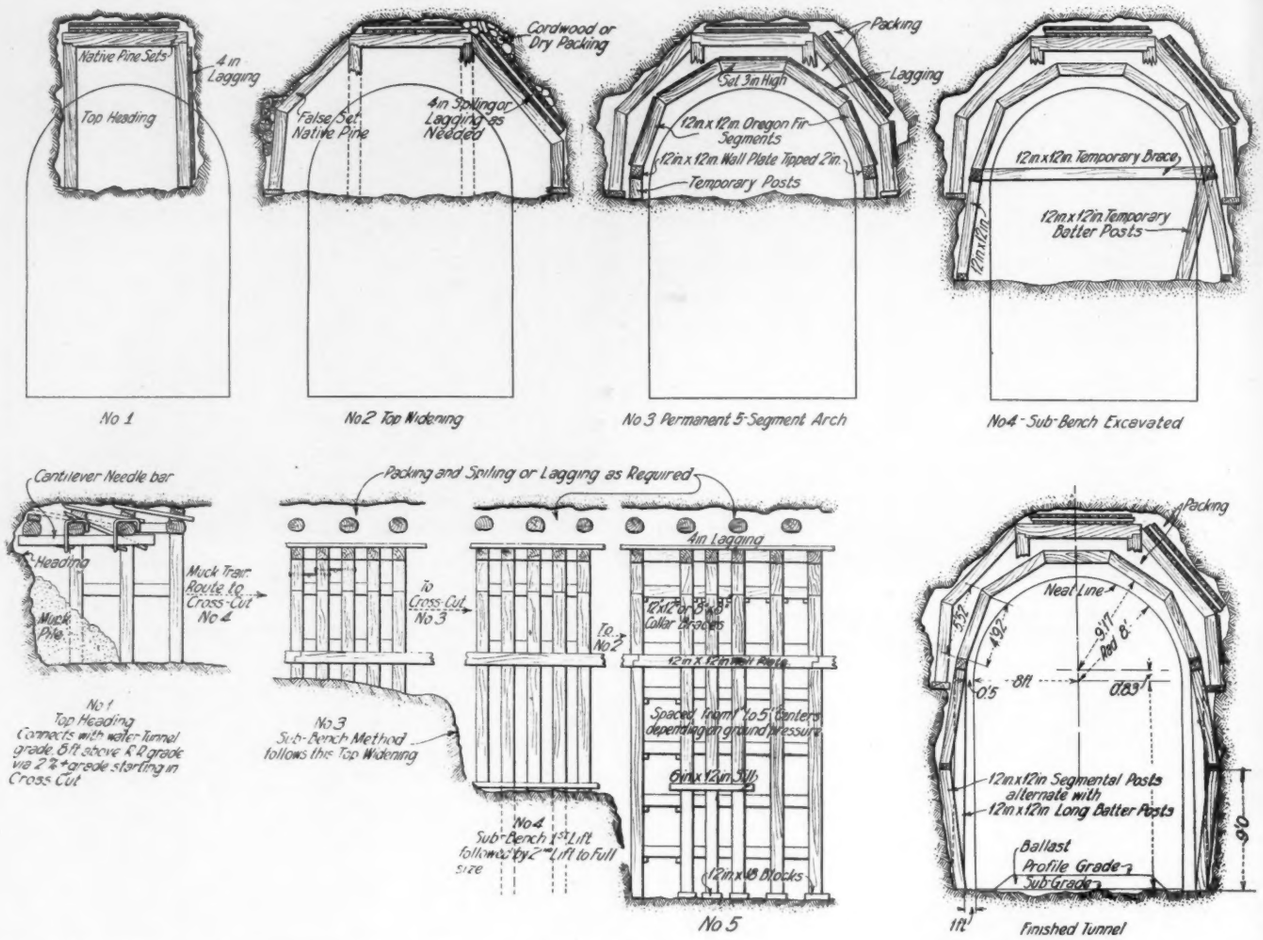
The single-benching method involves the use of needle beams to support the wall plates while the underlying rock is being excavated so that wall posts can be erected. The method answered well enough until ground was reached which developed inward pressures of sufficient magnitude to bend the 12x12-inch posts even when these were spaced only 24 inches between centers. Thereafter it was deemed wisest to remove the bench in two 8-foot sections, and the system of side timbering was modified accordingly. This has permitted the employment of a stronger form of timbering—one generally of sufficient strength effectually to halt any inward movement of the walls of the excavation. The square timbers are uniformly of 12x12-inch Oregon fir. The wall plates, which form the foundations for the segmental arches, are also of 12x12-inch stock and are carefully lined up by the surveyors both for direction and for elevation. These longitudinal timbers are canted inward with a top slope of two inches. Where temporary transverse braces are required these are inserted at every wall-plate joint to resist inward side pressure.

The pressures exerted by the surrounding rock have been so great as to deform and to damage even some of the 12x12-inch fir timbers; and in places the tops of the wall posts have been crushed by the movement of the overlying rock. Not only that, but this movement of the rock has necessitated the placing of heavy crosswise braces at points in the railroad tunnel. In short, it is manifest that the timbering will eventually have to be supplemented by a reinforced-concrete lining to check any further movement or collapse of the rock walls of the tunnel.

Space does not allow us to deal fully with all phases of the timbering work, but we are permitted to quote Chief Engineer Keays who has kindly furnished us with some interesting particulars. "Referring to the revised drawing, Stage No. 1, I might say that the needle beams and spiling are used only in the worst ground. In much of our work where the ground is better, the placing of the timber sets can be delayed until the muck is taken out—in which case the set is erected, posts and all at the same time, and the lagging placed on top of the caps without the necessity of driving ahead by the tail-block system.

"In the matter of widening out, Stage No. 2, 'winging out' as it is called, we do not always use spiling nor wing timbers, as indicated. Sometimes we dispense with the spiling, using lagging placed after the wing timbers are in position. And sometimes we dispense with the wing timbers also, as the original timber already set may be sufficient. Incidentally, this furnishes us with a rough way of determining the spacing of the permanent sets. For example, where wing sets and spiling are both used we set the permanent timbers on 2-foot centers; where only wing timbers are used we set the permanent timbers on 3-foot centers; where no wing timbers are used the permanent timbers are on 4-foot centers; and where no main-heading timbers are used the

Officials on a tour of inspection. From left to right, front row—V. A. Kauffman, C. C. Tinkler, E. R. Myer, R. H. Keays, J. V. Davies, W. P. Robinson, and W. Fowler. Rear—Burgis G. Coy, F. C. Hitchcock, D. W. Brunton, George Lewis, C. J. Wheeler, A. H. Baer, C. H. Leckenby, and C. A. Betts.



spacing is 5 feet, or up to a maximum of 6 feet on centers.

"In taking out the bench, the sub-bench method is used only in the worst ground. Where the ground is better, the timbers are placed on 4-foot centers or more, and the full bench is taken out in one operation—or, it would be better to say, that it is desirable to do so. It is impracticable, however, to change from one method to the other with any great facility. I might say furthermore that our methods for taking out the bench are still in a state of evolution, and we have in view some very important improvements in this operation. Our aim is to make more speed."

The permanent timbers are very carefully cut; and the segments of an arch when they are assembled in place are so fitted together that their own weight and not spikes serves to hold them in position. Any further pressure that may be exerted by the overlying rock tends to make the arch more resistant or rigid. One might expect that well-trained ship carpenters would be required for this work, but as a matter of fact only a few of the men engaged in preparing the timbers at the west portal are qualified carpenters. Most of the gangs that do this work have been trained on the job. This gives a good idea of the superior and the resourceful character of the men generally employed by the contractor. A suitably equipped sawmill and a carpenter shop at the west portal have been established to facilitate preparing the timbers.

Up to date, more than 5,000 feet of the tunnel at the west side has been timbered, whereas the original estimate, which was supposed to be liberal, called for a maximum of 1,500 feet of timbering. Each linear foot of timbering in the main tunnel costs anywhere from $125 to $150, and this accumulating outlay will add measurably to the total expense of the work. However, it is believed that this charge will be somewhat offset by the greater savings made possible through the easier and speedier driving of the tunnels on the east side of the mountain. Because of the more troublesome nature of the work at the west portal a larger force is necessary, and the number of men employed there is approximately 630. Work is carried on 24 hours daily expect on Christmas and the Fourth of July.

It might be mentioned that in winging out the top heading in the railroad tunnel the drill holes for blasting are made with "Jackhamers" and that only small charges of dynamite are used. This works out satisfactorily in the soft rock; and the blasting can be so nicely controlled that the near-by timbering is not disturbed. Now for a brief description of the way in which mucking is done when removing the top and the sub-bench in the railroad tunnel. The muck was handled for months by an Osgood air shovel having a dipper of 1-cubic-yard capacity. This machine did its work well and was able to handle in the course of two shifts all the muck brought down by drilling and blasting during three shifts. The Osgood shovel has recently been supplanted by an electrically driven St. Joe loader which requires but one man to operate it and is, therefore, somewhat more economical than the Osgood shovel under the conditions prevailing. That is, the rock is broken up small enough for the electrically operated machine to deal with it.

At the bench, the muck is loaded into 4-yard Koppel cars which move in and out of the railroad tunnel on track of 3-foot gage. An average of substantially 400 cubic yards of rock are moved daily from the headings at the west end of the project. The generally soft nature of the rock has been easy on the drill steels; and the two "Leyner" sharpeners in the blacksmith shop have had comparatively little to do. The piercing of hard rock has recently altered this phase of the job and, incidentally, has called into service powerful Ingersoll-Rand "R-72" drifters. This is especially the case at the heading of the water tunnel where two of these very efficient rock drills have been installed. The water-tunnel heading is about 500 feet in advance of the heading in the neighboring railroad tunnel and has seemingly reached harder and more stable rock than has previously prevailed on the west side. Where hard rock is met, the drill rounds and the charges of explosive are changed to meet the altered conditions.

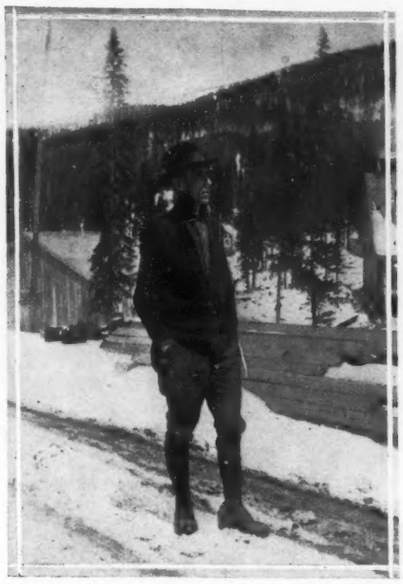
During the month of February of the current year an average daily advance of 21½ feet was made in the water tunnel at the west portal; and this performance promises well for the future, now that hard rock has been reached. In order that our readers may have an idea of the general progress on the undertaking, we give the figures for both the east and the west portal on March 1:

	East Portal	West Portal	Total	Finished
Water tunnel	8,137 ft.	6,767 ft.	14,904 ft.	46.2%
Main headings	8,112 ft.	6,238 ft.	14,350 ft.	44.5%
Crosscuts	315 ft.	315 ft.	630 ft.	48.5%
Railroad tunnel, full size	4,890 ft.	1,072 ft.	5,962 ft.	18.5%

The foregoing showing is an excellent one, and gives every assurance that the opposing headings will be holed through in time for Colorado's golden jubilee.

An interesting detail in connection with activities at the west portal has been supplied us, as we are about to go to press, by one of the executives of the Moffat Tunnel Commission, and has to do with special equipment devised to facilitate the enlarging of the railroad tunnel to the prescribed full size. To quote: "In order to expedite the work of enlarging through the 5,000 feet of heavy ground in sight, a traveling needle bar has been designed by General Manager George Lewis to support the roof timbers and wall plates while excavating with the air shovel and while placing the posts. This apparatus was installed in the railroad tunnel and began operating on the first of March.

"The device consists of two 48-inch steel girders, 60 feet long, rigidly braced 6 feet apart to carry cross-arms that reach under the wall plates and support them when wedged into the posts. As the bench is taken out, the girders are hauled ahead on rollers by means of a suitable hoist."



William Fowler, superintendent at the west portal.

V. A. Kauffman, resident engineer at the west portal.

Mess hall at west-portal camp.

NEW USE FOR HELIUM

BUBBLES of nitrogen set free in the blood of sand hogs and divers after they return to the normal atmosphere are the cause of "bends" or so-called caisson disease. Nitrogen, as is commonly known, constitutes the greatest part of the air we breathe. This inert gas does not help to promote the essential chemical actions which take place in the blood, and is, therefore, an element that might be dispensed with so far as breathing is concerned. Its one value would seem to be that of a medium serving to dilute or to regulate the quantity of needful oxygen taken into the lungs at each inhalation; and certain physicists have believed that the substitution of some other diluting gas would be advantageous.

To this end, the United States Bureau of Mines has carried on a series of experiments that have brought out, so it is announced, that helium can be mixed with oxygen to form a respirable atmosphere that will have all the virtues of atmospheric air at normal pressure and not be as harmful as atmospheric air when breathed for a more or less protracted period at an abnormal pressure. In other words, the helium-oxygen mixture is not as likely to produce bends when breathed by the sand hog or the diver.

The experts of the Bureau predict that the discovery will lead to a considerable extension of the pressure ranges under which divers and sand hogs can labor in safety; and, if this be correct, it will render it practicable for engineering tasks of certain kinds to be carried on under conditions and at depths today deemed prohibitive or extremely hazardous.

In the maintenance and repair of railroad tracks it is usually the practice to move section gangs from place to place on hand cars. As a result of studies made by the Pennsylvania Railroad that system is now providing motor cars for the purpose. So successful has been this change that 1,500 hand cars have been withdrawn and replaced by 1,000 motor cars. Aside from other advantages, it is claimed that the men reach their work in better physical condition.

Engineering Society Holds Memorable Banquet

THE Engineers Society of Northeastern Pennsylvania held its 28th annual banquet at the Hotel Casey, Scranton, Pa., on February 19, and the occasion was a memorable one because of the addresses made and the large attendance.

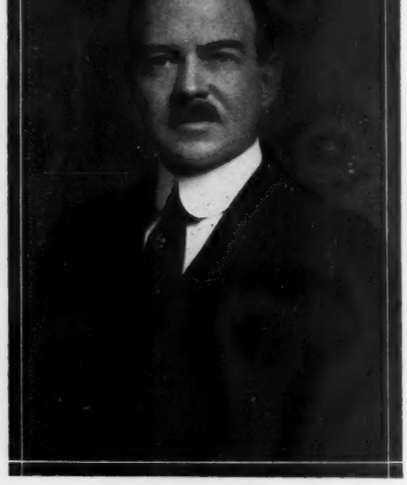
For more than a quarter of a century, this organization has been growing and extending its influence far beyond the state and the section of the state in which it was instituted. With the northeastern part of Pennsylvania as its focal point of interest, the society has naturally been long intimately identified with the development of the anthracite-coal industry which in turn, has its beneficial and essential contacts far and wide over a vast region in this country. Not only that, but the society has latterly done splendid educational work, which is deserving of the highest praise.

Frederick W. Gehle.

The banquet was presided over by Mr. Edward J. Mehren, vice-president of the McGraw-Hill Publishing Company, who filled with eminent success the office of toastmaster. Mr. Mehren reviewed some interesting aspects of the anthracite-coal industry, stating that competition with other forms of fuel had brought to the business at large the realization that coal has to be sold. He said: "People are thinking now in terms of other fuel than coal. They are thinking of the possibilities of coke, oil, gas, and certain forms of bituminous coal. This competition is a good thing, since it has led to an analysis of the problem from the selling standpoint with a view to ascertaining the good points of anthracite and the weakness of its rivals."

Preceding the speaker of the evening, Mr. Frederick W. Gehle, vice-president of the Mechanics & Metals National Bank of New York City, short addresses were made by Mr. Shelby D. Dimmick, president of the society during 1924, and by Mr. James W. White, the society's president for the current year. Both of these gentlemen spoke in the highest terms of the aims and the accomplishments of the organization.

As was expected, Mr. Gehle devoted his address in the main to an analysis of international relations and to their probable effect upon world trade. Mr. Gehle has made repeated trips to Europe during the last few years; and because of his personal and intimate knowledge of his subject he was able to present in a persuasive manner the facts of the situation and to carry his audience en-



James W. White.

thusiastically along with him. From start to finish, Mr. Gehle urged that the people of this country familiarize themselves with conditions abroad and then contribute to the solution of this manysided problem the thought which has so often enabled the American people to meet an emergency and to take the course best for all concerned. He pointed out, among other things, what has already been accomplished abroad by America through the efforts of General Dawes and his associates. But he emphasized that the United States must still continue to lend its aid in other ways to the economic stabilizing of Europe. Without stressing the fact he left it to be inferred that our coöperation was essential not only to the welfare of the peoples of Europe but also to our own welfare.

To quote: "I returned from Europe three years after the war, convinced that another world catastrophe was impending. One year ago the Reparations Commission, headed by General Dawes, formulated a plan to restore the peace of Europe and to bring Germany back into the family of nations. Today, an entirely different attitude prevails among the nations of Europe, and this change is intensely vital to the welfare of the United States.

"When the German currency was stabilized by the exchange of the old currency for the new at a rate of one trillion to one, the German people were bankrupt, but they thanked God. Today, Germany is one of the most stable nations of the world. I predict for Germany the greatest prosperity of any country in Europe and for her the greatest future of any nation in the world, except the United States.

"The United States is more prosperous than ever before. Our trade is greater than it ever was, with the exception of the two years following the war. We now enjoy an economic imperialism beside which that of Rome or Carthage becomes insignificant. Can we afford luxuries while our neighbors walk in rags? We must use our power on broad, statesmenlike lines. I am convinced that America will take the lead and show the nations of the world the road to prosperity, peace, and happiness."

Edward J. Mehren.

SALT FROM SEA WATER

THE salt industry in China is a government monopoly. Salt produced along the coast is bought by the government and sent to different centers to be sold at specified prices. Over the Yellow Sea and the Gulf of Pechili there is little rain, and atmospheric humidity is so low that natural evaporation goes on rapidly. Sea water in the shallows along the coast is, therefore, a concentrated brine which is further evaporated in "salt gardens" by the action of the sun. The water is carried into the gardens by the tide and by the aid of windmills. The yearly Manchurian output of salt from this source averages 150,000,000 bushels.

Dallas Completing a Magnificent Group of Terminal Buildings

This Progressive City of the Southwest is Rapidly Winning Nation-wide Prominence

By S. G. ROBERTS

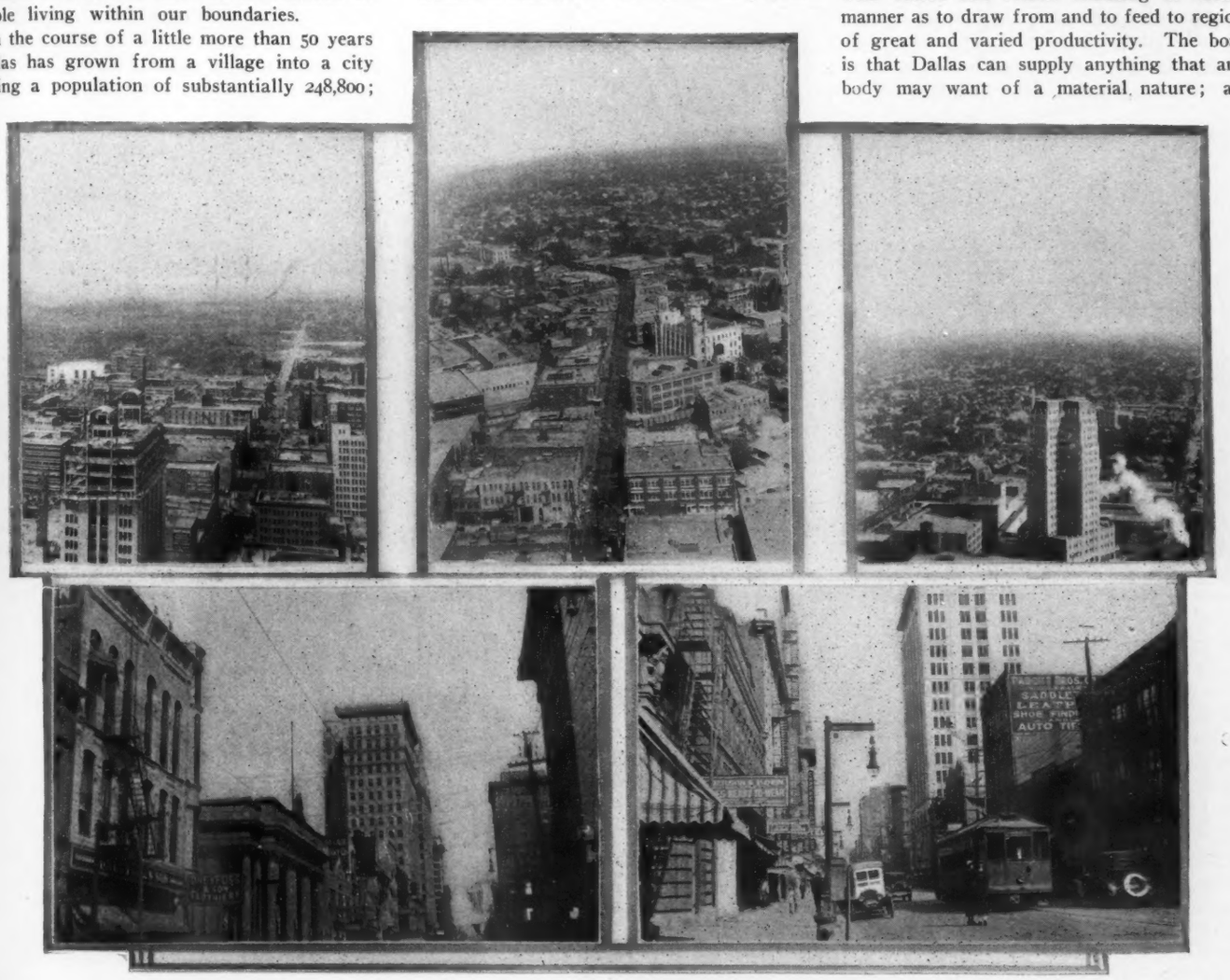
DALLAS is doing things; in fact Dallas is doing many things that are making her conspicuous in industry and in numerous departments of commercial enterprise. That the country at large is unaware of the rapid development of Dallas is only one more proof of the magnitude of the nation and of the localized interests of most of the millions of people living within our boundaries.

In the course of a little more than 50 years Dallas has grown from a village into a city having a population of substantially 248,800; and, within a radius of six miles, Greater Dallas has a population of approximately 350,000. Including its immediate suburbs, Dallas is, therefore, the largest city of the Southwest. This amazing expansion is not due to accident but is, in the main, the logical outcome of the earnest and the enthusiastic efforts of its intensely progressive men of business.

The Southwest is composed of Texas, Oklahoma, Arkansas, Louisiana, and New Mexico; and these five states, taken as a group, latterly have been growing faster than any other section of the United States. We are authoritatively informed that the Southwest is producing annually new wealth valued at more than $5,000,000,000 or, to express it in another way, at the rate of substantially $500 per capita.

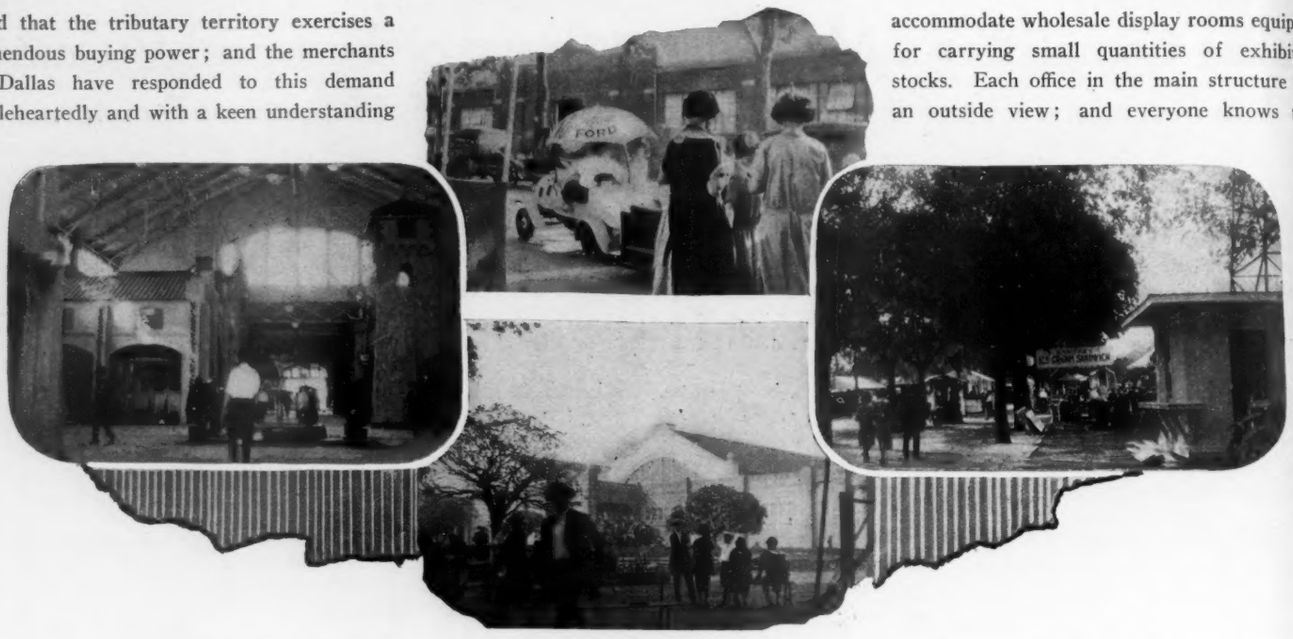
Dallas is situated at the center of population and near the geographic center of this wonderfully fruitful territory; and because of its strategic position and the alertness of its leading men the city has become what it is. In 1900, Dallas ranked 86th in population among the municipalities of the nation, whereas in the year gone it attained the 39th place in this scale of relative importance. About 25 years ago Dallas did a jobbing business totaling $15,000,000 in the course of a twelvemonth as against sales amounting to $800,000,000 in 1924. To a large extent it is this jobbing business that has greatly influenced the expansion and the financial growth of "The City of the Hour," as Dallas is very fittingly nicknamed.

Dallas is served directly by no fewer than eight steam trunk lines which provide the city with fifteen rail outlets radiating in such a manner as to draw from and to feed to regions of great and varied productivity. The boast is that Dallas can supply anything that anybody may want of a material nature; and this explains why the city has become the focal distributing point for a large part of the entire Southwest. Within a circle described about Dallas, and having a radius of 100 miles, there lie 8 Oklahoma and 46 Texas counties with an aggregate population of over 2,000,000 persons. These people are reached either by the trunk lines already mentioned or by interurban electric railways which do a large transportation business, especially in the form of express matter. It is not difficult to under-



Top—Different sections of Dallas as viewed from the tallest of her skyscraper office buildings.
Bottom—Typical street scenes in the heart of the business and shopping district of this wide-awake Texan city.

stand that the tributary territory exercises a tremendous buying power; and the merchants of Dallas have responded to this demand wholeheartedly and with a keen understanding



The State Fair held annually at Dallas is an event of great interest throughout the whole of the Southwest. The fair grounds are picturesquely arranged and boast numerous good-looking buildings and other attractive features.

of the part they are called upon to play in the upbuilding of the Southwest.

Not only is Dallas a bustling city, but it is also a beautiful city. Its residential section is an architectural revelation; and the skyline of the downtown district is marked by many imposing and towering business structures—some of them mounting skyward to heights that are duplicated only in cities of far greater size. And this brings us to the purpose of this article. As might be expected, Dallas has commodious warehouse facilities in order to take care of the enormous movement of inbound and outbound merchandise requiring temporary or even longer warehousing. But, extensive as these accommodations are, it has been found needful to amplify them and upon a scale that is truly monumental. We refer, particularly, to what is locally known as the Santa Fe Terminal.

The Santa Fe Terminal, now in different stages of completion, is composed of a group of four great reinforced-concrete buildings designed to meet the diversified requirements of the wholesaler, the jobber, or the territorial branch office. They will make it possible to display to advantage a multitude of commodities; to permit their periodic storage; and to facilitate their subsequent distribution in a manner that will make for the least lost motion. These are things that are to the interest both of the buyer and the seller.

The buildings that constitute the Santa Fe Terminal were designed by Lloyd R Whitson and F. Cowderoi Dale, Dallas architects; and when this magnificent project was first presented to the officials of the railroad that owned the ground the scheme was declared to be the conception of "dreaming men." The doubters said that Dallas could not support such an undertaking. Nevertheless, these skeptics came to think differently; and the manner in which space has already been contracted for is ample evidence of the feasibility as well as the desirability of the venture. The farseeing members of the Dallas Chamber of Commerce have been staunch supporters of the project from the very beginning and have played a potent part in its realization.

In its completed form, the terminal will be made up of four units. The most imposing of these is Unit No. 1, which consists of a typically up-to-date 19-story office building with an adjoining 10-story section intended to accommodate wholesale display rooms equipped for carrying small quantities of exhibition stocks. Each office in the main structure has an outside view; and everyone knows that such an outlook has a stimulating psychological effect upon those working in such an atmosphere. Each floor of the contiguous building is traversed centrally, from front to rear, by a wide corridor with glass walls; and the flanking spaces are divided into twelve display rooms, each 22 feet wide and 64 feet deep. Virtually every line of merchandise can or will be seen in this buyers' center. Unit No. 2, which is also ten stories high, has a floor-space area of something like 385,000 square feet, and is to serve for general warehousing. It is especially suited for storing carload lots of freight destined for transshipment and distribution to outlying points in the Dallas territory. Numerous large elevators make it possible to move the goods up and down within the building.

Architectural perspective of the four units forming the Santa Fe Terminal

Unit No. 3 is 100 feet wide, 245 feet long, and 8 stories high. A considerable part of this structure is to be occupied by the Southern Ice & Utilities Company which will have 500,000 cubic feet of space available for the cold storage of perishable products. This company will also furnish refrigeration to other tenants in the same building, if desired.

Unit No. 4 is to have a total floor area of 175,000 square feet; and, when ready, will be taken over by the United States Rubber Company. Perhaps it will help to a better idea of the magnitude of the Santa Fe Terminal if we mention that the foundations and walls require 60,000 cubic yards of concrete and 70,000 cubic yards of sand and gravel. All told, there will be used about 3,200 tons of steel; 20,000 square yards of roofing; and 1,400,000 square feet of flooring. In finishing the exteriors of the units a total of 1,800,000 face bricks will be employed, while 4,200,000 bricks will be utilized for the inside walls. In the neighborhood

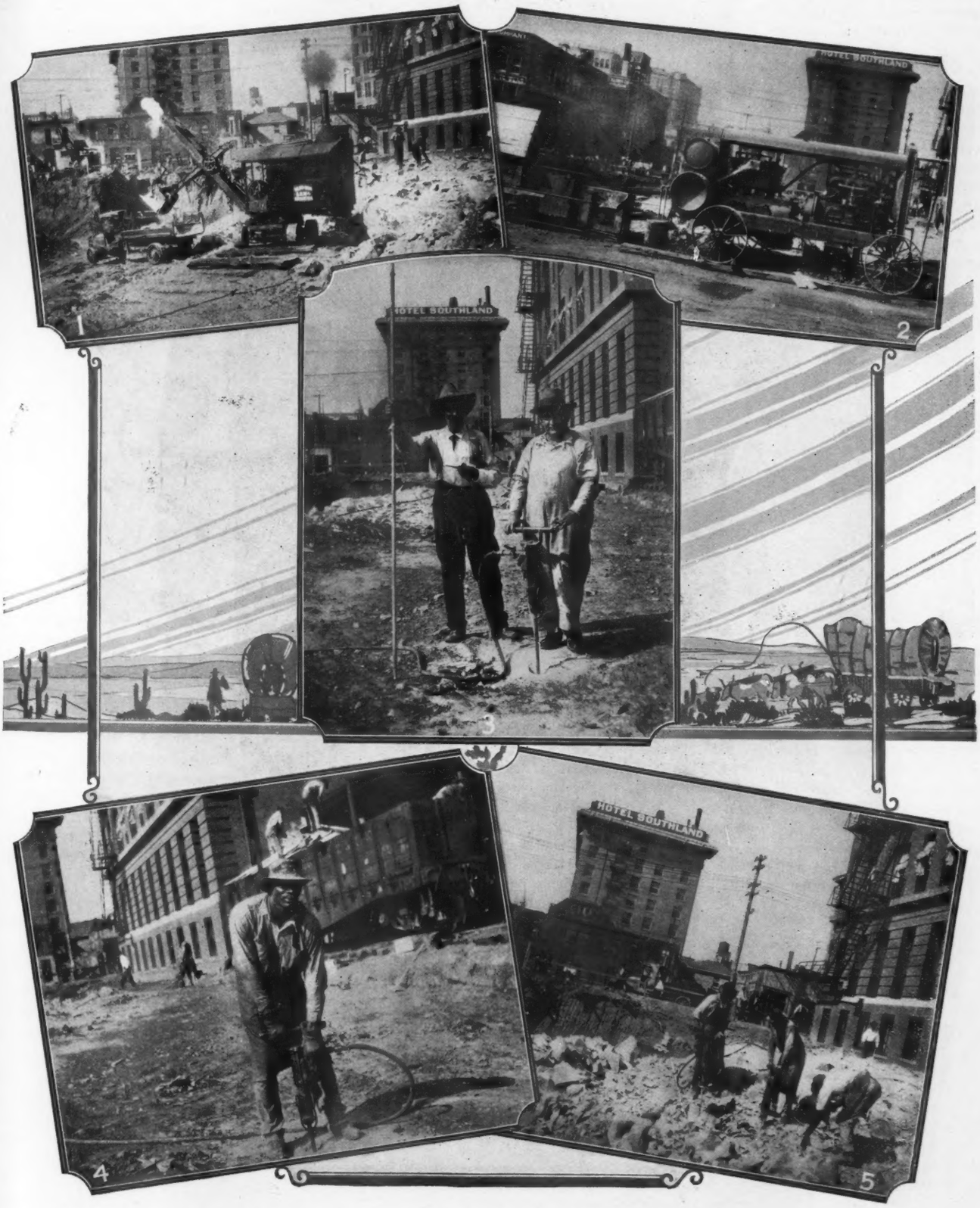


Fig. 1—Steam shovels and motor trucks have speeded up the removal of blasted rock.
Fig. 2—This 9x8-inch Type Twenty Ingersoll-Rand portable compressor furnished much of the air required for the operating of "Jackhamers" and paving breakers.
Fig. 3—Henry Dies, popularly known as "Old Henry," is seen at the right. He has been for years the competent rock-drill foreman of the Vilbig Brothers Company.
Fig. 4—Preliminary stage in clearing the site for one of the terminal units.
Fig. 5—When fitted for the service, the "Jackhamer" proved especially effective in drilling the gummy Austin chalk which underlies the Santa Fe Terminal.

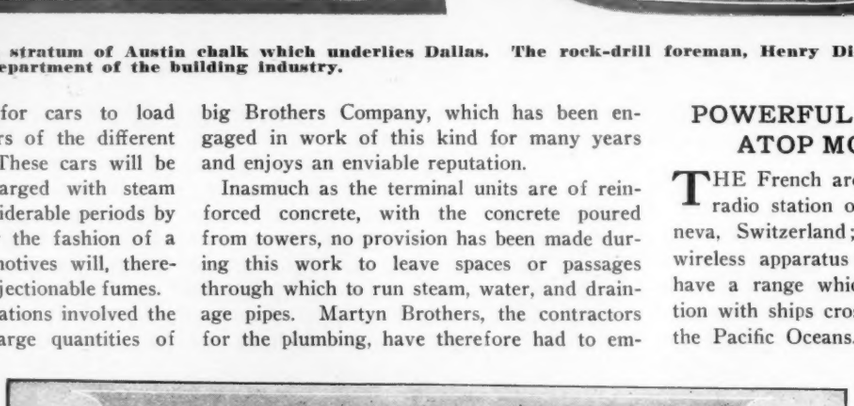
of 600 workmen have been engaged on the job; and these details help to explain how the terminal will represent, at completion, an outlay of $5,000,000.

In order to prevent interference with traffic on the adjacent streets, the warehouses are flanked on two sides by covered concourses, fifteen feet wide, where trucks can load and unload. Five lines of railroad track will underrun the four units below the street level and will connect with surface tracks at the rear of the terminal by ramps 1,800 feet long. This will make it practicable for cars to load and to unload in the cellars of the different sections of the terminal. These cars will be shifted by locomotives charged with steam and made operable for considerable periods by encasing their boilers after the fashion of a thermos bottle. The locomotives will, therefore, produce no smoke or objectionable fumes.

Digging into the stratum of Austin chalk which underlies Dallas. The rock-drill foreman, Henry Dies, is a well-known local figure in this department of the building industry.

Excavating for the foundations involved the drilling and blasting of large quantities of Austin chalk which had previously proved decidedly troublesome because of its soft and gummy nature—tending to grip the drill steels and to prevent penetration. This difficulty was overcome by utilizing Ingersoll-Rand "Jackhamers" of ample rotating power and equipping them with steels that kept the holes cleared of cuttings. Air for the driving of these "Jackhamers" was furnished by 9x8-inch Type Twenty and 8x8-inch Type Fourteen portable compressors. The excavating was done by the Vilbig Brothers Company, which has been engaged in work of this kind for many years and enjoys an enviable reputation.

Inasmuch as the terminal units are of reinforced concrete, with the concrete poured from towers, no provision has been made during this work to leave spaces or passages through which to run steam, water, and drainage pipes. Martyn Brothers, the contractors for the plumbing, have therefore had to employ "Jackhamers" and paving breakers to get through the floors and the walls—air to operate these tools being provided by a 5x5-inch Type Twenty portable. The Dallas Power & Light Company has had to dig trenches in the Austin chalk, to cut passages for conduits, to excavate manholes, etc., in order to make the needful electrical installations. That company likewise utilized "Jackhamers" and paving breakers; and one of its 7x6-inch Type Twenty portable compressors was the source of the motive air.



Skyline of downtown Dallas as seen from the notable concrete viaduct which links Dallas with Oak Cliff lying on the south side of the intervening Trinity River.

POWERFUL RADIO STATION ATOP MOUNT SALEVE

THE French are planning to erect a great radio station on Mount Salève, near Geneva, Switzerland; and it is said that the wireless apparatus to be installed there will have a range which will enable communication with ships crossing both the Atlantic and the Pacific Oceans.

An observatory is also to be built there by the French which, when finished, will house the most powerful telescopes in the world. The largest of these instruments is to be constructed by George Willis Ritchey and Louis A. Bauer, American scientists.

Four years will be required to complete the wireless station and the observatory; and it is reported that Mount Salève will become the seat of the international meteorological office.

Compressed Air Hastens Construction of Largest Hockey Arena on this Continent

By F. A. McLEAN

IN the world of sport, well-nigh every country has achieved international standing as the leading exponent of some particular form of recreation, such as horse racing, skiing, golf, baseball, etc. Thus England has long been considered the home of cricket and soccor, Scotland of golf, the United States of baseball, and Canada of hockey.

Although baseball, football, racing, skiing and many other games are carried on extensively, most Canadians regard hockey, with its lightning-like rushes and momentary thrills, as peculiarly their own game, and many professional, semi-professional, and amateur teams engage in this sport. As a matter of fact, from coast to coast, it would be hard to find a community in which some of the citizens do not take an interest in this game. It is thus appropriate that Montreal, the greatest city in Canada, should now be able to boast the largest artificial-ice hockey arena on the North American continent.

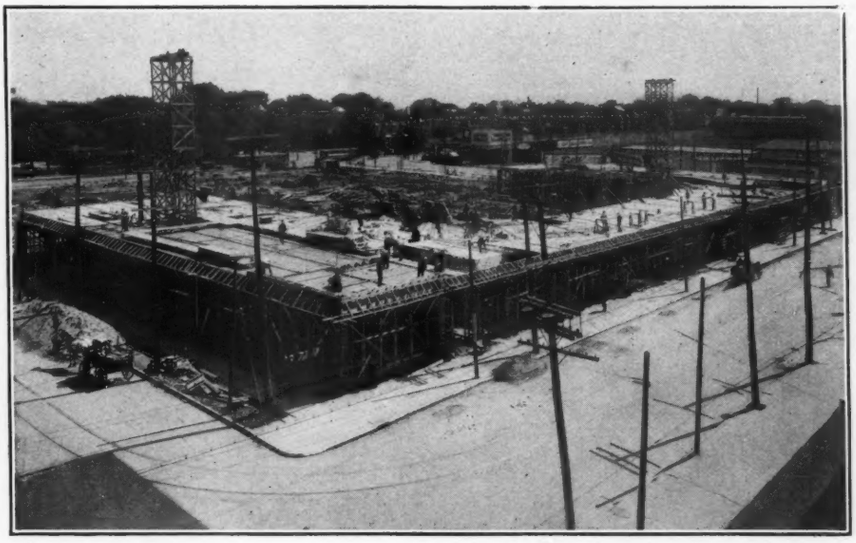


Photo E. W. Bennett.

How the Forum Building looked after the work had been underway only two months.

This splendid structure, known as the Forum Building, presents an example of unusually rapid construction. Work on it was started in June, 1924, and hockey matches actually took place there before the end of November. Pneumatic tools and other labor-aiding devices played an important part in helping to make this record possible.

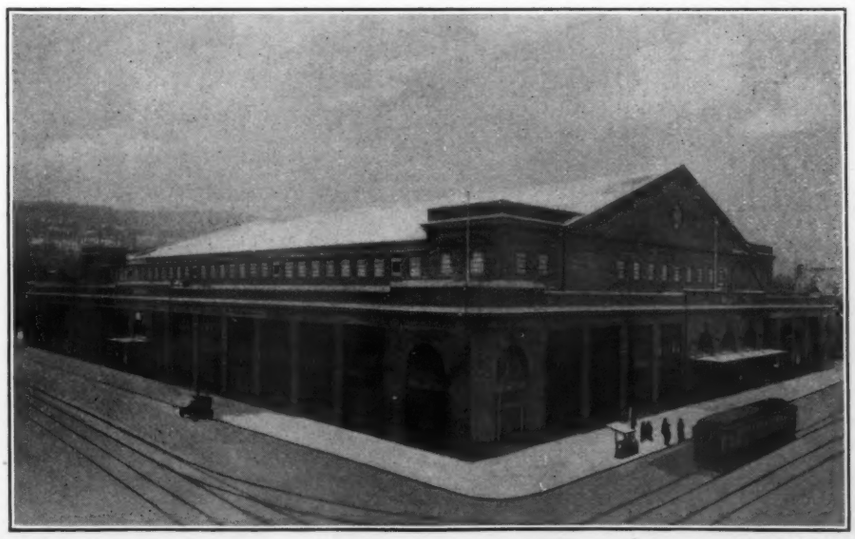
The building, designed by Mr. John S. Archibald, of Montreal, covers an area of 105,000 square feet, has a frontage of 295 feet, and a depth of 360 feet. It has a seating capacity for 8,500 people and standing room for 3,000, while another 2,500 can be accommodated when boxing matches are staged. The seats are so placed as to give all spectators an unobstructed view; and beneath the seats there is a large amount of storage space for equipment, etc. The skating surface, which has an area of 17,000 square feet, is so arranged that the ice can be melted, the water drained off, and a wooden floor laid within a period of eight hours.

On the main floor, facing the street, there are 35,000 square feet for stores, showrooms, etc. This space has been provided for the purpose of assuring not only a year-round revenue but of adding to the sum total of the income. By adopting a similar plan, many smaller communities could afford to erect structures of this kind for the benefit of the younger generation. Where it is impossible to set aside part of such an amusement place for commercial purposes, the refrigerating equipment needful for a hockey rink could be utilized during the summer months for the manufacture of ice. The rear of the Forum Building is arranged for the convenience of horse shows. An easy ramp leads thence to a section of the floor above where horses can be stabled. A total of 34,000 square feet of this floor is also used for bowling alleys.

The framework of the building, which is fireproof throughout, is of reinforced concrete beam-and-slab construction—the seat steps being formed of reinforced-concrete risers 4 inches thick. These risers act as joists and transmit the loads to girders supported by reinforced-concrete columns. The wooden seats for the spectators are placed on the steps. The main roof is carried on steel trusses having a span of 160 feet. Each of these trusses, said to be the largest in service in Canada, weighs 25 tons. The roof is of gypsum slabs with felt and gravel covering, and has a slope of 20 degrees.

Approximately 600 tons of structural steel and 18 tons of rivets were used in the framework. The rivets were of ⅞-inch and ¾-inch diameter and varied in length, the longest being 6¼ inches. Operating air for the pneumatic tools on the job was supplied by a 10x12-inch class "FR-1," straight-line, steam-driven Ingersoll-Rand compressor which kept four riveting gangs busy. The structural steel was fabricated and erected by the Dominion Bridge Company, of Montreal.

The arena is heated with hot air and this air is distributed by fans placed under the steps and between the seats. The rest of the building is heated by a low-pressure steam system. Of course, in providing the



The structure as it appeared at the end of six months when ready for occupancy and use.

heating plant, it was necessary to consider not only the ice—which must be kept in condition while a match is in progress—but the comfort of the audience as well. Both these conditions have been met and, in consequence, hockey games can now be witnessed in comfort and without the danger of taking cold.

The refrigerating plant installed is known as the ammonia-compression and brine-circulating system and consists of two ammonia compressors having a refrigerating capacity of 35 tons each. These compressors are belt driven by 50-H.P., 3-phase, 60-cycle, 550-volt motors. The condensers are of the double-pipe, counter-flow type and have a total capacity of 70 tons. The open-top brine-storage tank has a capacity of 165,000 gallons.

The refrigerating coils are made of 1½-inch, extra-heavy black piping and cover the entire skating surface, which is 85 feet wide by 200 feet long. The pipes, which are placed 4⅝ inches apart, are carried on wooden sleepers and are held in place by galvanized-iron clips. The outlet and the inlet of each of these pipes are provided with 1¼-inch brine valves. At each end of the rink there are two 8-inch headers, and to these the pipes are connected. In other words, there is a delivery and a return header at each end, thus assuring a continuous flow of cold brine through the coils on the skating floor. As previously mentioned, the piping can be hooked up with the heating system for the purpose of thawing the ice and preparing the rink for a theatrical production or some other purpose. Two 6-inch centrifugal pumps are employed to circulate the brine, and each is direct connected to a 10-H.P. electric motor. These pumps have a capacity of 400 Imperial gallons per minute when circulating the cold brine through the rink coils.

The operating principle of the refrigerating system is the same as that in all ammonia plants—ammonia gas being compressed in the compressors and then forced over to the condensers where it is liquefied and held in the liquid receiver. From the liquid receiver the gas is allowed to expand through the brine coolers and is then sucked back in the form of gas to be recompressed in the compressors. The brine in the coolers is made of calcium chloride of sufficient density to avert any likelihood of freezing. After the brine has been chilled in the brine coolers it is circulated through the rink coils and returned to the tank.

The arena stands on the site of an older and smaller structure that was designed for similar purposes; and before excavating for the new building could be started it was necessary to remove many tons of concrete, brick, and stone. For this work and for excavating, the general contractors, The Atlas Construction Company, employed paving breakers and "Jackhamers"; and the air to drive these tools was supplied by a 5x5-inch Ingersoll-Rand, Type Twenty, portable compressor mounted on a standard 1-ton Ford truck. This well-known firm, which does a wide variety of contracting work in and around Montreal, finds mobile power plants of the type just referred to valuable aids in building operations of various kinds, in street and harbor-improvement work, in trench digging, etc.

Courtesy Canadian National Railways.

Left—Double ski jump from the Mount Royal slide. Right—Part of the initiation to membership in a snowshoe club. Bottom—Horse racing on an ice track where the competition is keen because of the cold and invigorating air.

CANADA'S WINTER SPORTS ARE VARIED AND IN THEM WOMEN ARE KEEN PARTICIPANTS

Paving breakers, operated by air from a portable compressor, cutting old concrete and hard soil in digging trenches for the foundation of the Forum Building.

Winter sports have long attracted visitors to Montreal during the season when Nature clothes that city in a mantle of snow and ice. Within the past few years, hotels, railroads, and other enterprises catering to the traveling public have carried on a well-directed campaign to make Montreal "the winter-sports capital of America." These efforts are bearing fruit; and each year an increasing number of tourists go to Montreal to enjoy sleigh riding, dog derbies, skating, skiing, snowshoeing, tobogganing, etc.

Clean sports are of benefit to young and old alike; and the citizens of Montreal can take just pride in this latest addition to the city's sources of amusement. To those engaged in the construction industry, the principal interest in this new structure lies in the speed with which it was erected—representing, as it does, an excellent example of what can be done by taking advantage of modern building equipment.

STENCH ALARM EFFECTIVE

AN effective demonstration of the stench alarm system to warn miners of impending danger was recently given at the Utica Mine, Hibbing, Minnesota. According to the *Mining Journal-Press*, a quart of ethly mercaptan was fed into the air line at the power house by means of a lubricator. The resulting vapor penetrated the workings so rapidly that the 130 miners at work were warned by the pungent smell and were all out of the mine in 29 minutes. The mine in question covers an area of 80 acres; and to reach the men farthest from the shaft the odor had to be carried half a mile. These men walked that distance; climbed the 300-foot shaft, and were in the dry house within the time mentioned.

Fireworks add to the picturesqueness at night of Montreal's outdoor winter sports.

MANUFACTURING NOW OUR LEADING INDUSTRY

IN THE old days America was a great farming country, depending largely upon agriculture for its wealth and stability. It is an old saying, that if we have good crops we may expect good business. The following official figures indicate that from almost any angle manufacturing is now our leading industry. According to the 1920 census, the number of persons engaged in the various major industries of the country are:

Manufacturing	11,000,000
Agriculture, including forestry and animal husbandry	10,900,000
Trade	4,200,000
Transportation, including rail and water transportation, express, telegraph, and telephone companies	3,000,000
Building	1,700,000
Mining	1,000,000

Statistics as to the value of the products or the services of these industries are not available in comparable form. However, the following figures for the years 1919-1920 are of some significance:

Total value of manufactured products	$62,000,000,000
Value added to raw materials by manufacture	24,700,000,000
Value of agricultural products	21,400,000,000
Expenses of Class 1 railroads	6,800,000,000
Estimated volume of retail trade	34,000,000,000
Mineral and quarry products	3,100,000,000
Building	3,600,000,000
Building, for 1924	5,000,000,000

FLOWING ASPHALT WELL

ASPHALT is so widely and familiarly known as a solid that a tale of a flowing well of it comes to us as a surprise. The well in question is at Newport Beach, Calif., and was sunk for oil to a depth of 1,800 feet when an accident stopped operations. It was then cemented and perforated back to 750 feet, when asphalt began to flow. As the 4½-inch casing was too small to permit the viscous material to issue readily, another well was sunk to a depth of 1,000 feet. By circulating hot water around the casing of this well a flow of from 50 to 80 barrels was obtained. Other wells in the same system are now producing 200 barrels a day. The asphalt cannot be conveyed like oil through pipe lines, but is transported entirely by trucks.

Plans are underway to improve the Port of Quequen, Argentina, at an outlay of $15,000,000. It is proposed to prolong the breakwaters and quay for coastwise and overseas shipping; to dredge the channels to the anteport and the basin to a depth of about 33 feet; and to construct an electric power station, a refrigerating plant, and grain elevators.

Submarine Cutting Torch Put to Novel Service

By SIDNEY MORNINGTON

THE big plant of the Solvay Process Company at Syracuse, New York, obtains the water used by it from nearby Lake Onondaga. This water is drawn into the plant through a 72-inch cast-iron main extending outward on the bottom of the lake for a distance of 1,200 feet. The pipe is generally 15/16 inches thick.

Not long ago, the management found that an insufficient quantity of water was being delivered through the main to the plant, and the only explanation was that the pipe had become partly filled with sand or other refuse drawn in from the lake. Manifestly, the only practicable remedy was to have the main cleaned by divers. The problem was how to make this possible without grave risk to the underwater workers. As the accompanying diagram shows, the pipe lies at a depth ranging from 30 feet to more than 50 feet; and the strainer or offshore end is situated a little less than a quarter of a mile from the connecting well close to the edge of the lake. In other words, assuming that the divers could work inward from each end, each would have to crawl toward a common point 600 feet distant and within a conduit already partway filled with an obstructing deposit.

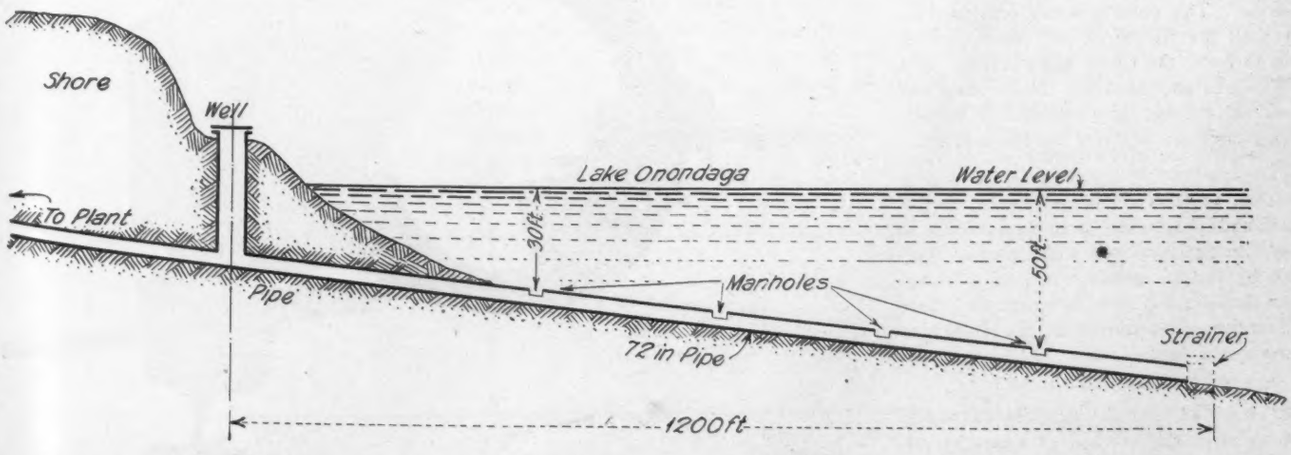
Divers getting ready to place one of the manhole covers. Suspended at right is a section cut out of the pipe, to which will be fitted the square plate at left forming a manhole plug and cover.

The only solution which seemed a safe one called for the cutting of a number of manholes at nearly equidistant points in the exposed and upturned side of the main between the strainer and where the pipe is completely covered by earth. In this way, it was believed that the divers could work inside the main and clear it out without being subjected to needless hazard. The next thing was to have these openings cut; and the job was awarded the International Submarine Company, which is the owner of an efficient subaqueous torch suited to work of this nature.

The apparatus employed by the contractor, in addition to torches, diving gear, etc., included a 50-kilowatt generator. This outfit was shipped to Syracuse and placed aboard the towboat *Florence*, which served as a floating base of operations and as a source of motive steam for driving the turbine of the electric generator. Steel flasks or tanks, charged with highly compressed oxygen, supplied the gas which is used in conjunction with the electric arc to enable the torch to fuse and to cut metals under water. This plant was assembled aboard the *Florence;* and the day following everything was in readiness to cut the openings in the submerged main.

The following details have been supplied by one of the men engaged in this rather unusual undertaking. To begin with, a diver took down a weighted wooden template and placed this on top of the pipe where the first of the holes was to be burned. Then a ground wire from the generator was attached to the cast-iron main by means of a large C-clamp; and with this done the diver returned to the surface for his cutting torch. When the diver emerged, his suit was found to be coated with a thick film of brown oil; and he reported that the pipe and the lake bed adjacent to the conduit were covered with this heavy oil. The slippery oil made it very difficult for him to maintain a position on top of the pipe where it was necessary for him to work when using the torch.

On the first day, the diver started burning with his torch at 9.40 a. m. and stuck to the job until noon. In the afternoon he worked from 1.10 to 3 o'clock, at which time the water supply aboard the tug was nearly ex-



Cross section of intake pipe illustrating manner in which the large main was entered by four manholes cut with the submarine torch.

hausted. As the *Florence* could not use lake water in her boiler, operations had to be suspended for the day so that she could run back to the canal terminal for more water. Inasmuch as the tug was the only craft available for the work in hand, an effort was made to install aboard of her additional tanks so that she could carry enough water to last for an 8-hour day. Two tanks were therefore placed on her deck, using all the space there available for that purpose. Even with this provision, not enough water could be carried to supply the boiler for more than five hours.

The water problem in connection with the tug and the presence of the blanket of submerged oil, which hampered the diver and made it hard for him to maintain a steady arc with his torch, prevented the completion of the first manhole until eight days had elapsed. The second and third holes were cut, respectively, in the course of three days; but repairs to the towboat's boiler halted operations for a while so that the fourth hole was not finished until three weeks after the job was started. So much for the service of the submarine torch.

With the four openings cut in the main, divers used those holes to enter and to leave the main while engaged in cleaning it. The obstructing deposit was salt cake, and had to be broken loose with small crowbars. This was decidedly toilsome work. The heaviest deposits were at the pipe joints where roughness first led to the arrest of the inflowing material and gradually produced large accumulations. After the conduit had been cleaned from end to end, the divers filled the joint spaces with a smoothing coat of cement to eliminate the conditions which had induced the clogging formation.

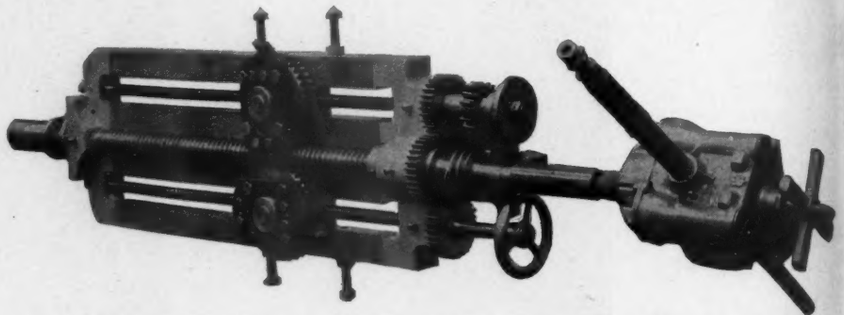
While the divers were clearing out the main, covers were made for the manholes. These covers were formed by using the cut-out-pipe sections and bolting to them rectangular iron plates 5/8-inch thick. The attached plate in each case overlapped the associate piece from the pipe by three inches all around. A ring bolt in the center of each of these manhole covers made it possible to lower each cover into its intended resting place—the overlapping top plate serving to hold the plug, so to speak, in position. The outside water pressure, together with the weight of the cover, further helping to make the cover more secure. The ring bolts will also facilitate the hoisting and the removal of the covers should it become necessary later on to clean the main again.

The total amount of foreign capital invested in Canada has risen from $450,000,000 in 1900 to over $4,640,000,000 at the present time. In 1900 by far the greatest part of this capital was British; but there is reason to believe that American investments in the Dominion are now in the lead.

It is estimated that the quantity of paying ore in sight in the quicksilver mines at Almaden, Spain, is sufficient to produce approximately 1,000,000 flasks of mercury.

PNEUMATIC DRILLS DRIVE PORTABLE TOOLS

IT IS becoming quite the practice in railroad repair shops to use air-driven drills as motors to do a variety of services. The accompanying photographs show two interesting applications of drills of this description for the purpose of operating portable machine tools.



Using an Ingersoll-Rand air drill to operate a cylinder-port facing machine.

One of the pictures illustrates a No. 2 nonreversible air drill fitted up to drive a crank-pin turning machine, which is employed to true up locomotive crank pins. The drive of the large ring gear, which carries the cutting tool, is effected through a worm and gear. As the ring turns about the crank pin the cutting tool is fed forward. A somewhat similar machine is utilized for dealing with crank pins of inside-cylinder locomotives, such as are extensively used in Great Britain.

The second apparatus—a cylinder-port facing machine—serves to reface slide-valve seatings on worn locomotive or other cylinders. The machine is bolted to the valve chest; and the power of the air drill, applied through the long worm gear, turns the cutting tool which refaces the valve seat. Kindred tools are employed to rebore cylinders and piston valve chambers and to face the various seatings on fire-box casings and on boiler shells.

All these air-drill-operated tools were devised by Beyer, Peacock & Company, the well-known locomotive builders, of Manchester, England; and it is claimed that their use considerably expedites repair work.

Because of a lack of refrigerating facilities, which prevents the storage of fresh foodstuffs in quantity, Cuba is one of the largest per capita consumers of canned goods.

GLUE NOW MADE IN THE FORM OF "PEARLS"

COMMERCIAL glue has heretofore been sold in sheets produced by the slow and otherwise expensive process of evaporation. By a new method, now being employed in England, glue is turned out in the form of "pearls." The hot glue is dropped through a perforated plate into a cooling liquid which, of course, cannot be water. A mixture of carbon tetrachloride with benzine has been found suitable for this purpose.

The globules of glue at first float on the surface, but as they cool and solidify they sink to the bottom, whence they are taken away by a traveling conveyer and dried in the open. The process takes but a small fraction of the time required by the older method; and it has been found that glue in the shape of pearls is more convenient to handle and more economical in use.

Crank-pin turning machine actuated by a No. 2 Ingersoll-Rand air drill.

Application of the Diesel Engine to the Power Problem of Electric Railways

By J. KENNEDY MANN

INASMUCH as power is one of the major items of the operating cost of electric street railways, it may be considered worth while to examine, briefly, the possibilities of the Diesel oil engine as a means of reducing this element of cost.

For several years, street-railway executives and engineers have been coming to an acceptance of the fact that, if power is to be generated by steam, large prime-mover units are essential to economical production. To achieve this end of themselves has been, in most cases, impossible, inasmuch as their loads are not usually of sufficient size to permit the installation of large generating plants. This has resulted in the street railway looking outside of itself for a solution of this problem, and its power has consequently been purchased in constantly increasing quantities from large power companies.

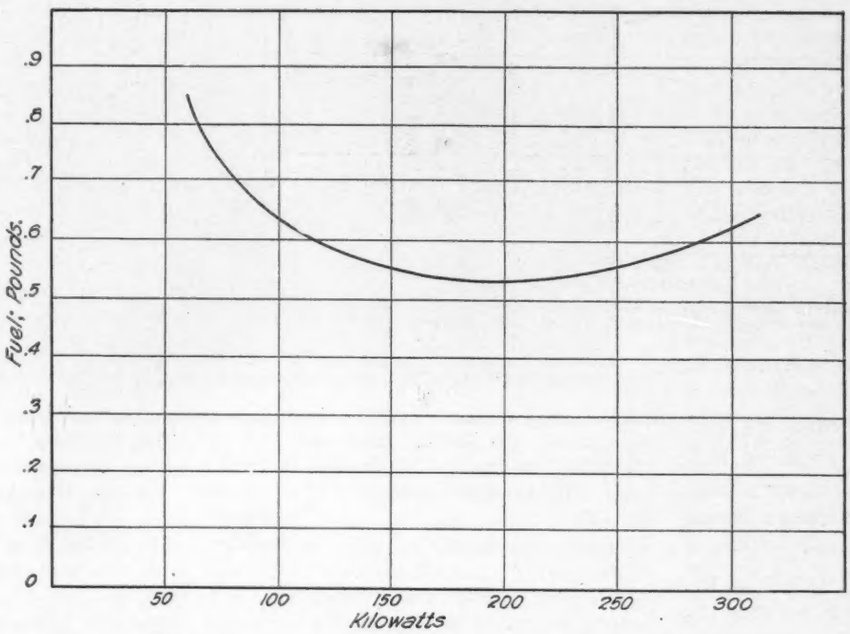


Fig. 1—Typical fuel-consumption curve for a 250-kilowatt, Diesel-electric, direct-current unit.

The power problem of the electric railway differs materially from that of practically every other industry in that it demands direct-current energy fed to as many points as it is economically practical to do so. The present method of meeting this condition is by the use of rotary converter substations transforming and converting high-potential alternating current to direct current of a voltage suitable for use at the car motors.

All this involves serious waste in transmission, transformation, and conversion, losses amounting in many cases to from 12 to 15 per cent. for which the electric railway must pay. It would seem to reflect the actual power cost more correctly were the railway to calculate this as at the substation bus bars in the form suitable for car propulsion rather than as energy at the high-tension bus of the central station.

Because the railway needs direct current at numerous load centers it is interesting to consider the use of small self-contained, Diesel-engine-driven power stations to take the place of rotary converter substations. In this country, central-station engineers and executives have looked upon the Diesel engine with a hypercritical eye. Although they invariably concede that this type of prime mover stands out preëminently as the most efficient transformer of heat energy into mechanical energy, the fact remains that until comparatively recently the Diesel engine did not receive the consideration its merits warranted.

Perhaps the most interesting feature of this type of engine is that its efficiencies are but relatively little affected by the size of the unit. Coupled with this desirable quality is another—namely, its sustained efficiency at fractional loads, as shown in Figs. 1 and 2.

Too often has the Diesel been condemned of the economic crime of too high installation costs and resulting high fixed charges. As far as the electric railway is concerned, in order to get an unbiased viewpoint, one must include, in comparing a central steam plant with substations, the total cost of these latter stations and their transmission lines, and compare this figure with the total installation cost of a series of relatively small Diesel-electric plants.

For comparative purposes let us consider railways whose power demands can be met by a central station of 5,000 kilowatts and having eight rotary converter substations of 500 kilowatts each. The cost of this, including transmission lines, will be between $200 and $225 per kilowatt of direct-current plant installed. On the other hand, eight Diesel-electric stations of 500 kilowatts each, and each consisting of two 250-kilowatt units, would cost between $170 and $185 per kilowatt. Furthermore, voluminous records show that a Diesel-electric station can be successfully and well maintained at a cost not exceeding $2.75 per kilowatt-year.

Touching on depreciation, there are and have been sufficient Diesels in operation for a long period of years to indicate a life, with proper maintenance, of not less than twenty years. Depreciation due to obsolescence need scarcely be feared when one realizes that the Diesel engine of today exceeds by only a scant

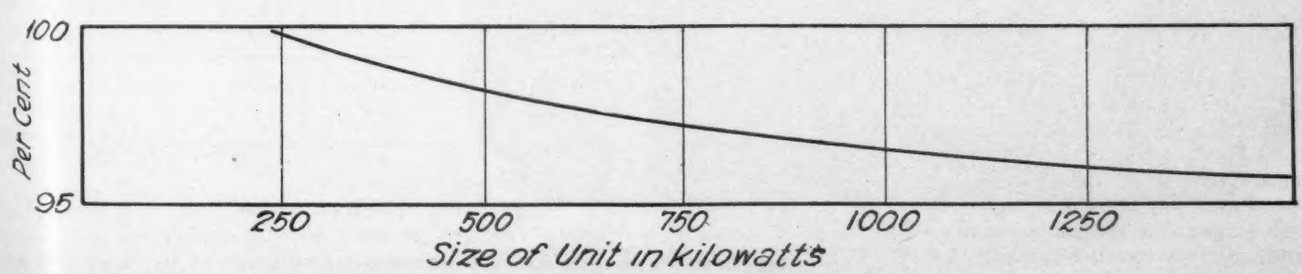


Fig. 2—Relative efficiencies of units of various sizes at continuous full load.

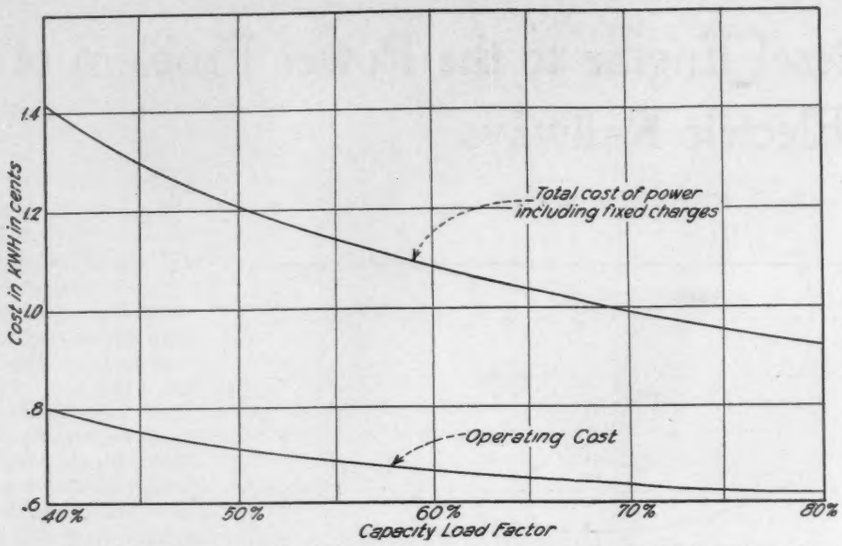


Fig. 3—Effect of capacity load factor on cost of power of a 500-kilowatt station operating 20 hours a day for 365 days a year.

12 per cent. the efficiency of the Diesel of twenty years ago.

Reliability of operation is, perhaps, the chief essential in power supply of the electric railway. Rotary converters are extremely satisfactory machines from this standpoint. When substations suffer an involuntary shutdown, the trouble is very seldom chargeable to the rotaries and their adjuncts; but too often the transmission-line failures impair the reliability of substation operation. With the small Diesel station, the absence of these transmission lines removes that source of unreliability.

As far as the engine-generator sets are concerned, many records show them capable of operating for very long periods without shutdown. For instance, study the performance of marine Diesels on which depend the safety of a rapidly increasing number of large ocean-going passenger ships. Certainly it is hard to conceive conditions where reliability is of greater moment than in marine work.

With a series of small Diesel-electric stations at the various load centers of an electric-railway system, the dropping out of one engine unit would have no serious effect on the service as a whole. A drop of bus voltage would occur at the station which suffered disability. This would result in the immediately adjacent stations assuming the load of the crippled unit.

In order to get an idea of the cost of power production with stations of this kind, let us consider for a moment a station of 500-kilowatts capacity, operating 20 hours a day for 365 days each year, with an average load during the operating period of 300 kilowatts and an annual output of 2,190,000 kilowatt-hours. The installation cost of such a station would be about $92,500. The cost of power for such a station, under the conditions assumed, would be made up as follows:

FIXED CHARGES

Interest on investment, at 6%.....	$5,550.00
Depreciation, 5% sinking fund for 20 years with a 10% scrap value	2,517.00
Taxes and insurance, at 1%.....	925.00
Total fixed charges.....	$8,992.00

MANUFACTURING COSTS

Fuel, 2,190,000 Kw.h. x .54 lb., 157,680 gals., at $0.05.....	$7,884.00
Lubricants, .5 gal. per 1,000 Kw.h., 1,095 gals. at $0.60.....	657.00
Attendance, 3 men at $1,800 per year	5,400.00
Repairs, 250-Kw-years at $2.75....	687.50
Water, 1,210,000 gals., at $0.12 per 1,000 gals.....	145.20
Total manufacturing costs.....	$14,773.70

Or, at the rate of 6.7 mills, adding to this the fixed charges per unit, the total cost of power per unit would be 1.085 cents, as per Fig. 3.

This cost is for power in a form suitable for car propulsion.

Briefly summarizing the advantages of a series of small Diesel-electric stations in lieu of the present system of a large central station with transmission lines and substations, they offer:

Low cost of power.

Power generated in the form in which it can be used at the cars.

No transmission lines with their losses and vulnerability.

No conversion and transformation losses.

No standby losses, as the engine does not consume fuel when it is not producing power.

The possibility of a general power interruption throughout the system is eliminated.

Freedom from the recurring threat of shutdown due to coal strikes.

It is interesting to note that even if the price of the oil fuel were to increase 100 per cent., the cost of power, including overhead, would only increase about 33 per cent., as indicated in Fig. 4.

From the foregoing, it would seem that in pondering the power problem, the engineers and executives of the electric-railway industry

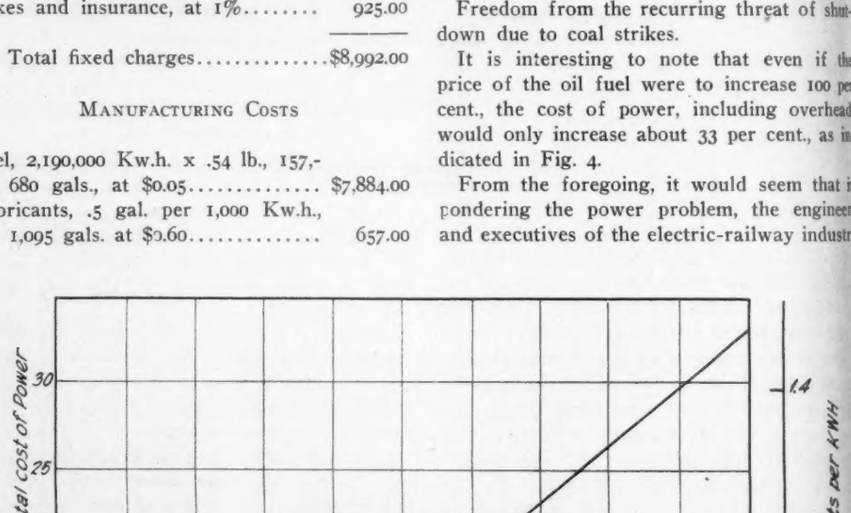
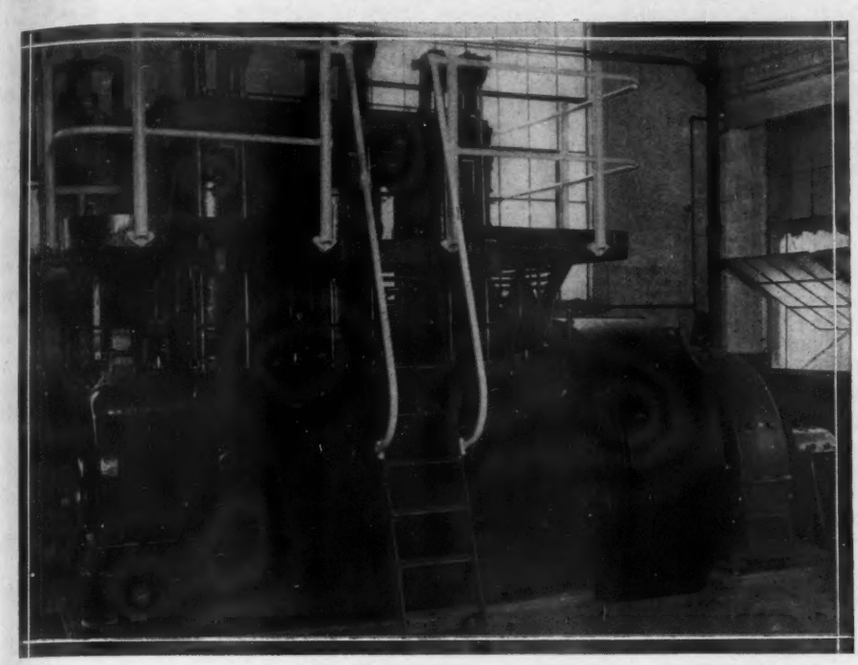


Fig. 4—Graph showing the effect of increasing oil prices on the total cost of power of a station equipped to generate 500 kilowatts. Average load 300 kilowatts, with plant running 20 hours a day every day in the year.



A 300-H.P. Ingersoll-Rand oil engine direct connected to a generator.

should give due weight to the claims of the small Diesel-electric plants.

FLAXSEED AS A PROTECTION FOR STEAM BOILERS

FLAXSEED, so it has recently been claimed, is now doing effective work in preventing the formation of scale and in the removal of scale already formed in steam boilers. The apparatus by which it is distributed is named a filtrator, and consists of a cast-iron cylindrical shell with an inner perforated cylinder filled with raw flaxseed. The filtrator is connected directly with the boiler and is continually filled with steam at full boiler pressure. The steam permeates the flaxseed, extracting from it slowly a mucilage which condenses and forms the protective emulsion.

This emulsion descends drop by drop into the boiler and mixes with the circulating water, thereby coming in contact with all the boiler surfaces. Furthermore, it coats with a thin film particles of hard matter suspended in the water—thus preventing them from adhering to the surfaces. These particles gradually settle and are ejected when the boiler is blown down. In this way, so it is said, is obviated the formation of scale when very hard water or sea water is used. When scale has already formed, the flaxseed emulsion penetrates the cracks which always exist and loosens the scale, which is then thrown off and carried away by the circulation.

Mexico has a population slightly in excess of 14,000,000. Of this total not more than 5,000,000 can purchase imported goods other than foodstuffs.

The production of electric power in Italy now reaches an annual total of from 4,000,000,000 to 5,000,000,000 kilowatt-hours.

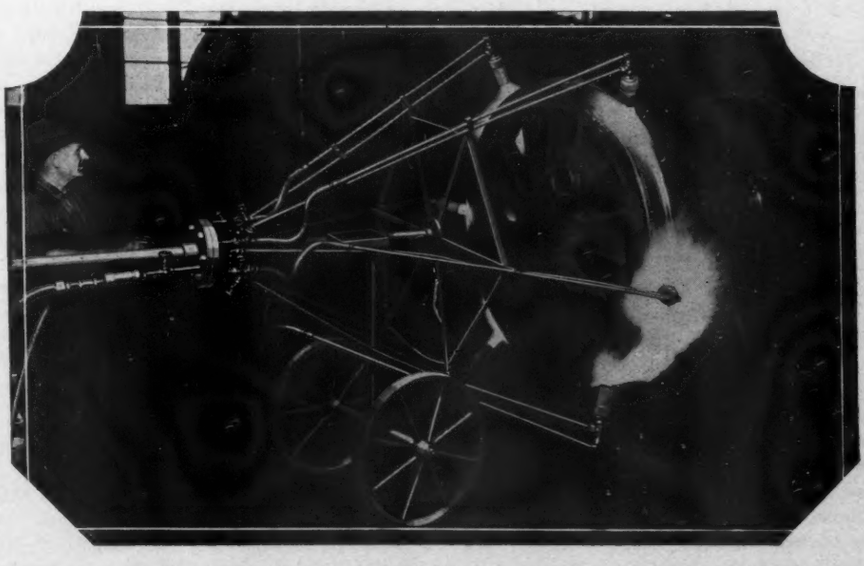
HOW DRIVING WHEEL TIRES ARE NOW HANDLED

MOST of us probably imagine that the driving wheel of a locomotive is a single casting. This is not the case. Driving wheels are made up of centers, that may be either cast iron or cast steel, upon which are shrunk steel tires that stand the wear and tear of frictional contact with the rails upon which a train moves. Notwithstanding the fact that the metal chosen for these tires is of a composition calculated to withstand severe treatment in service, still the tires are deformed and worn away by the sweeping, grinding action that takes place between the wheels and the rails. The tires are also ground away by contact with the brake shoes, which are brought into play to slow down an engine or to hold it back when descending a stiff grade with a heavy train shoving against it from behind.

Every now and then the tires must be removed and replaced by new ones. Formerly, operations of this sort were rather long and tedious, because it required considerable time to expand the tires by heating so that they could be knocked off by striking them with heavy sledge hammers. For the sake of those that may not be familiar with the subject, it should be mentioned that the practice is to bore out the inner surface of a tire so that its diameter will be a trifle smaller than the diameter of the wheel center upon which it is to be fitted. This difference is overcome by heating and expanding the tire; and when so enlarged the tire is slipped over the wheel center and left to cool and to contract. The bond between the two is then a firm one.

The most up-to-date method for heating and expanding tires, either to put them on a wheel center or to remove them, utilizes a symmetrically arranged series of oil torches operated by compressed air. These torches insure an even distribution of the heat so that the entire rim is heated uniformly and is not distorted as was so often the case in the past. Not only that, but the pneumatic oil torches produce hotter flames which shorten to a marked extent the time required to bring about the desired degree of expansion; and considerably less effort need be expended in fitting on or withdrawing a tire. The accompanying illustration shows an equipment of this nature employed in the shops of the Lehigh Valley Railroad. By means of this apparatus much time and labor are saved. It used to take seven men to do the boring and to apply the tire of a locomotive driving wheel: today, one mechanic, a helper, and a laborer do the work.

About $700,000,000 of American capital is now invested in Mexico, and mostly in oil, mining, timber, and land.



How the tires of locomotive driving wheels are now heated to facilitate removal. These oil torches, operated by compressed air, have greatly reduced the time required to perform this operation.

Compressed Air Magazine

—*Founded* 1896—

Devoted to the mechanical arts in general, especially to all useful applications of compressed air and to everything pneumatic.

Business and Editorial Offices:
Bowling Green Building, No. 11, Broadway, New York City. Tel. Bowling Green, 8430

Publication Office: Somerville, New Jersey

TERMS OF SUBSCRIPTION

$3 a year, U. S. A., American possessions and Mexico; all other countries $3.50 a year, postage prepaid. Single copies, 35 cents. Back issues more than six months old, 75 cents each.

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EDITORIALS

MANUFACTURING OUTSTRIPS FARMING IN AMERICA

THE progress of America during the past century has been distinctly in the direction of industry and manufacturing. The first census taken in Washington's time showed that over 90 per cent. of the population lived on farms. Today our farm population is less than 30 per cent. The wealth, that is, the buying power, of this 30 per cent. shows that it is only about 20 per cent. of the total buying power of the country. During the past 20 years the per capita food production of America has not increased. On the contrary, there is a tendency to decline.

If we eliminate that part of the country devoted to cotton raising we find that less than one-quarter of our population now resides on farms. Furthermore, farming has been very much diversified. At one time wheat was our most important industry, but today the value of eggs exceeds that of wheat. Even the meat and dairy industries are more important than grain production. Fruit is also a source of great wealth in many states. The value of the products of manufacturing industries, as shown by official figures, is more than double that of the farms.

In the old days it was said that we could not have prosperity without good crops. Crop failures created depressions and financial calamities. Now that industry is predominant there is more stability in our economic life. This is easily understood when we realize that farming is not as elastic or as easily controlled as the products of industry. Crops, once planted, take months to mature and to reach markets: they cannot be curtailed or increased to meet changed conditions. The manufacturer, on the other hand, increases or decreases his product from month to month to meet changed conditions. If, for instance, he has stock orders for 100 engines underway in his works and he finds that firm orders are falling off; that prices are going down; that general business conditions seem to be unfavorable; he cuts the output of his plant from 100 to, say, 50 engines—putting the unfinished parts in his inventory. The reverse action takes place where conditions are improving and greater activity is warranted.

We talk of the Federal Reserve System as being the great stabilizer in business. It is a stabilizer, but its action is principally directed towards financial stability. The great industrial stabilizer in America today is manufacturing.

FLORENCE LAKE TUNNEL HOLED THROUGH

WE have previously described at some length in our pages the main features of the Southern California Edison Company's Big Creek hydro-electric project which has been underway since 1911. It will be recalled by our readers that the undertaking included the driving of a master tunnel, so to speak, right through Kaiser Mountain for a distance of 13½ miles. This tunnel, known as Florence Lake Tunnel, was holed through on the 18th day of February and many months in advance of the schedule. Here, again, is an accomplishment made possible largely through skilful applications of compressed air and highly efficient air-driven rock drills.

Florence Lake Tunnel is 15 feet wide and 15 feet high, and it pierces a mass of hard and solid granite forming the backbone of a mountain towering 3,000 feet above it. This passageway links the reservoir at Florence Lake with another great impounding area lying below it and known as Huntington Lake. By means of these basins, descending waters from the slopes of the adjacent mountains will be caught and held in reserve throughout each year for the continuous generation of an enormous block of electric energy. In short, the holing through of this tunnel marks the climax of a vast engineering task which embraces an area 72 miles long and 32 miles wide and which is to contribute to the convenience, the comfort, and the industrial activities of a potential population of 6,000,000 people.

Much of this work has been carried on in the heart of mountain fastnesses which were well-nigh inaccessible when operations were started; and to reach the strategic points it was necessary to build roads around the faces of precipitous and nearly vertical cliffs and to open up highways on the mountainsides over which structural materials and supplies of all sorts could be moved. A force of substantially 3,000 men has been engaged upon the various parts of this enormous job which, when completed, will entail a total outlay of approximately $375,000,000. Surely this is a magnificent example of public-service enterprise, and it should be duly appreciated by those ultimate consumers who will have only to throw a switch or to press a button to draw on a current of electricity produced for them, perhaps, hundreds of miles away.

NATIONAL MUSEUM OF ENGINEERING AND INDUSTRY

WHAT buoys and beacons are to the mariner, mileposts are to the traveler along the highway—each of these marks telling the wayfarer not only how far he has gone but how much nearer his objective is. This knowledge of progress has its equivalent in other departments of life and serves to encourage and to spur men on in all sorts of endeavors. In the absence of this knowledge advance becomes more or less groping and the urge to greater or to sustained effort is likely to be lacking.

How many of us are appreciatively aware of the way in which we, as a people, have forged ahead in engineering and industry since we established our national independence nearly 150 years ago? It is probably no exaggeration to say that comparatively few of us have a comprehensive conception of the amazing strides which we have made in these directions. A general understanding of this progress would be of incalculable value not only as an inspiration but as a means towards lessening waste effort.

Recognizing this, a group of representative leaders in industry and the professions have called into being a corporation which has for its goal the establishment of The National Museum of Engineering and Industry, to be erected in the City of Washington and to be under the direction of the Smithsonian Institution.

This great central museum will house thousands of valuable relics and inventions now in the custody of various Government institutions and departments, and it will receive from private industry and private organizations historic items of inestimable value which can thus be assured proper preservation. Besides this array of milestones passed by ourselves, there will be developed the parallel stories of industrial advance in other countries. Where original inventions or models are not available for display, the gaps will be filled with faithful replicas, drawings, and illustrations, so that no link in the chain of events shall be lacking.

With the parent institution thus functioning in Washington, the present plan calls for the establishment of local museums of industry in New York, Chicago, and other great American centers. The building in Washington will cost, so we are informed, about $4,500,000. Adequately to endow the work will, in all

likelihood, involve an additional sum of $3,500,000. To place authentic replicas in the several branch museums will require the current income from $2,000,000. In all, a fund of $10,000,000 will be needed to carry out this project.

The aim of the organizers is to do for us what other nations in a kindred but to a less pretentious degree have done for their peoples. There is ample evidence of the benefits that have been derived from these institutions by the citizens of those foreign countries and by the world at large.

WHEN IS MAN AT HIS BEST

THIS question has probably agitated the minds of many people and on many occasions. Professor KARL PEARSON recently undertook to answer this question while delivering a lecture at University College, London, England. According to that eminent scientist, man reaches his prime at the age of 27. Needless to remark, the professor provoked a good deal of discussion, and he has aroused a flood of caustic comment somewhat similar to the reaction induced by the late Sir WILLIAM OSLER'S definitive assertion that little of value had been accomplished in the world by men that had passed their fortieth year.

Professor PEARSON'S declaration, although of doubtful accuracy, is nevertheless valuable because it will make thousands of people think. It will lead to self-analysis, introspection, among thousands of people that commonly pay little heed to the morrow and who live so much in the present that they are unmindful of whither their labors and their talents are carrying them or may carry them. Much can undoubtedly be gained by striking an occasional trial balance of one's capabilities and by pondering dispassionately upon how they are being employed.

At this moment, we do not know what represented the sum of that prime which Professor PEARSON put at the comparatively immature age of 27 years. We are disposed to believe that he had the physical rather than the mental attainments in mind. Indeed, well-nigh every human being has his particular age at which he reaches his relative best; and this best is not necessarily to be judged by the years he has lived but by what he has accomplished at any time within those years.

A power-transmission line six miles long and carrying a current of 13,000 volts was transplanted recently in its entirety without cutting off the flow. The system parallels a highway from Martinsville to New Vienna, Ohio; and the widening of the roadway compelled the lateral resetting of the line. A crane mounted on a big truck lifted the poles one after another and placed them in new holes dug 10 feet to one side. On an average, 16 poles were thus moved daily, or the line was shifted at the rate of 0.6 mile a day.

PROFITABLE SCIENCE IN INDUSTRY, by Dwight T. Farnham, James A. Hall, R. W. King, and H. E. Howe. An illustrated work of 291 pages. Published by The Macmillan Company, New York City. Price, $3.50.

THIS book was conceived by its associate authors with the thought in mind of carrying to the general public a message telling of the part played by research and the man of science in a number of radically different departments of our complex industrial life. The authors are to be commended for the clearness of their treatments of the various subjects discussed.

A great many people look upon the manufacturer as a thoroughly practical man and upon the scientist as essentially a theorist; and the object of the volume in question is to dispel this misunderstanding and to show how intimately the two men are united in a common effort to be of service to the world at large. The book is filled with interesting facts and figures and is entertaining and informative throughout.

MEN AND ISSUES, by George Wharton Pepper, a book of 308 pages with illustrations. Published by Duffield & Company, New York City. Price, $2.50.

WHATEVER may be our personal views regarding the weight to be attached to the opinions of certain of our national legislators, there is no disputing the fact that George Wharton Pepper, senior senator from Pennsylvania, is an outstanding figure not only in Washington but among the guiding geniuses of America.

This volume of his speeches on many subjects, which should interest us and even concern us, is deserving of most careful consideration. In discussing issues, men, and events, Senator Pepper has focused upon them a ripe scholarship and mature judgment. We cannot too strongly commend this book to all that would be better and more understanding citizens of this great republic of ours.

BIRD ISLANDS OF PERU, by Robert Cushman Murphy, assistant director of The American Museum of Natural History. A profusely illustrated work of 362 pages. Published by G. P. Putnam's Sons, New York City. Price, $5.00.

THE author tells us in his preface: "The specific objects of the expedition upon which this book is based were to investigate the oceanic conditions which are responsible for the abundance of life in Peruvian waters, as well as the interrelationships and distribution of this life; to make collections in the ocean and upon the islands for use in zoölogical studies and in the preparation of museum exhibits; and to obtain motion pictures of the bird life of the coast and of the reorganized Peruvian guano industry."

So much by way of prelude. In the pages that follow, Doctor Murphy has written a fascinating account of many things not mentioned in his preface and he has developed in a highly entertaining manner, as well, an account of the bird life of those Peruvian islands which have long been a source of actual or potential wealth by reason of the amazing accumulations there of plant food. This plant food, so helpful to the farmer, has been amassed through centuries on utterly barren surfaces. Because of the part that the cormorant has played in the course of ages in the upbuilding of these vast deposits of guano, Doctor Murphy has with some reason called it "the most valuable bird." His book should be read by a great many people, and will certainly give pleasure to those that do read it whether or not they are directly interested in the commercial or the agricultural value of guano, as such.

Safety in the use of explosives is the title of a booklet issued by the Hercules Powder Company, Wilmington, Del. This brochure contains a wealth of authoritative information and should be of value to anyone that has to employ modern explosives frequently or at intervals in his regular calling. The booklet is well illustrated, and the pictures have been chosen as an aid to carrying home the lesson or message desired. Copies can be had free upon application.

THE United States Bureau of Mines, Washington, D. C., has recently sent out the following list of new publications:

BULLETIN 228. Estimation of underground oil reserves by oil-well production curves, by W. W. Cutler, Jr. 1924. 109 pp., 2 pls., 26 figs.

TECHNICAL PAPER 332. Conditions affecting the activity of iron oxides in removing hydrogen sulphide from city gas, by W. A. Dunkley and R. D. Leitch. 1924. 26 pp., 9 figs.

TECHNICAL PAPER 338. Smoke-abatement investigation at Grafton, W. Va., by Osborn Monnett and L. R. Hughes. 1924. 29 pp., 13 pls., 3 figs.

TECHNICAL PAPER 348. Gas masks for gasoline and petroleum vapors, by S. H. Katz and J. J. Bloomfield. 1924. 30 pp., 8 pls., 7 figs.

TECHNICAL PAPER 371. Coke-oven accidents in the United States during the calendar year 1923, by W. W. Adams. 1924. 35 pp.

MINERS' CIRCULAR 28. Sanitation in mines, by R. R. Sayers. 1924. 16 pp.

In an Indiana power plant a flashlight was set off beneath a circuit carrying 13,000 volts. The two wires were about 9 inches apart; and, under ordinary conditions, 90,000 volts would have been necessary to cause an arc-over. The flash powder, 4 feet below the wires, caused a dead "short," which threw open the main breakers on the circuit. The phenomenon was probably caused by dust and hot gases rising between the bare wires.

PROLONGING THE LIFE OF RUBBER TIRES

THE valuable properties of vulcanized rubber depend, as is well known, upon the addition to the rubber of a small amount of sulphur and upon the heating of the combination to a certain temperature. The deterioration of the vulcanized rubber by hardening and cracking is a chemical process due to the combustion of the sulphur. At ordinary atmospheric temperatures the sulphur slowly but surely oxidizes. The increasing temperature to which pneumatic tires are subjected hastens this action.

Dr. G. Niese, in the *Allgemeine Automobil Zeitung,* states that the oxidizing action is effectively checked by a preparation, *Spare-gum,* marketed by a Leipzig firm. Its action depends upon a negative catalyst which greatly retards the aging process, almost eliminating it. The product is to the tire what leather preservative is to shoe leather.

GIGANTIC STEAM BOILER

A BOILER recently put into service by the Allegheny County Steam Heating Company, Pittsburgh, Pa., is thought to be the largest in the world, and is the first of four similar units planned for the complete plant. It is a water-tube boiler of the cross-drum type. The drum is 60 inches in diameter and 34 feet long, and there are 1,173 tubes 24 feet long which, with the wall-cooling tubes, give approximately six miles of 4-inch tubing.

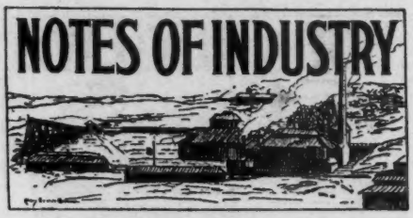
The heating surface amounts to 32,750 square feet—three-quarters of an acre, and on this basis the boiler is nominally rated at 3,000 H.P. However, it is capable of operating continuously at three times that capacity. The maximum rate of evaporation is approximately 200 tons per hour, or about 400 per cent. of the nominal rating. Steam is generated at 150 pounds, although the boiler is designed for 190 pounds. Pulverized coal will be used. A fuller description of this unit is given in *The Locomotive.*

CANADIAN HYDRO-ELECTRIC DEVELOPMENTS

A NEW power plant is to be erected on the Batiscan River by the Shawinigan Water & Power Company, according to a recent announcement. This development is to have an installed capacity of 20,000 H.P. and a potential output of 30,000 H.P. The project is to cost approximately $1,500,000, and is to be completed about May, 1926.

One of the features of this undertaking is the driving of a tunnel, nearly three-quarters of a mile long, which is to have a diameter of thirteen feet after the reinforced-concrete lining is in place. It will be driven under the present power plant, which will continue in operation. The proposed dam will back up the waters of the Batcasin River to Chute Platte, a distance of 2 miles.

"Politeness," so Henry Ward Beecher once remarked, "is like an air cushion—there may be nothing solid in it, but it eases the jolts wonderfully."



The Japanese Institute of Nutrition claims that a certain flour from fish powder actually does increase human stature, and Dr. Victor G. Heiser, director of the Rockefeller Foundation in the Far East, endorses the claim. The flour is made from cooked and boned fish; and, incidentally, it is found to be a by-product in the manufacture of chemicals. It would seem that a corrective has thus been discovered for short stature which, it is claimed, is the result of an unbalanced diet over long periods of years.

Since the beginning of present-day commercial Japan, in 1868, that country has enjoyed a steady and a remarkable growth in foreign trade. During the two following decades her combined exports and imports never exceeded 80,000,000 yen annually, and in 1888 the 100,000,000-yen mark was reached. In 1924, that is, for the first eleven months of that year, her total exports and imports fell just short of 4,000,000,000 yen.

Vacuum cleaners have been very successfully employed in cleaning the streets of Los Angeles, Calif. Four cleaners are in use; and an average surface of 71,507 square yards is swept per day per cleaner at a cost of 21.55 cents per 1,000 square yards. In the year ending June 30, last, 82,655,000 square yards were swept. The cost of operation, given in the report of the city engineer, is $15.42 per day per machine.

In certain silk-producing areas the cocoon is no longer thrown on the scrap heap, as it has been found to be rich in oil. This oil can be extracted by pressing, and is useful in the manufacture of soap. Furthermore, the residue contains phosphorus and can, therefore, be employed as a fertilizer.

Constantinople is the only city in Turkey that has a central electric power plant. This station generates alternating current which is transformed to 550 volts for electric street-car service and to 110 volts for lighting and other household uses. Except for these purposes, electricity is little used.

Based on the crops harvested during the past five years, Canada stands second among the world's wheat producers. The United States, which has thirteen times Canada's population, holds first place.

Europe, on account of her dense population having a relatively high purchasing power, is by far the United States' most important customer, taking over half of our total exports.

An effort is now being made by Hawa leaders to encourage the establishment in islands of such manufacturing enterprises Hawaii can support.

The development of rail transportation India has been extremely slow—the length of her railways being only 38,000 mi This mileage serves an area of 1,803,000 sq miles and a population of 320,000,000. It claimed that an additional 100,000 miles necessary to meet the needs of the country

The first gas plant in the United St was established in Baltimore in 1816.

The United States continues to lead world in the production of rayon—artifi silk, and its output in 1924 amounted 38,850,000 pounds.

The iron and steel mills of France are being run at about 75 per cent. of their capa ity. With the restoration of Alsace-Lorra France almost doubled her facilities for p ducing iron and steel; and it is estimated her present plants, if run to capacity, wo have an annual output of from 40,000,000 43,000,000 tons.

New aluminum produced in the Uni States in 1924 was worth $37,607,000, an crease of almost one-third over the value the output in 1923.

In Russia it is peremptorily forbidden open any new factories for the manufact of white lead, or to import it from abro After Jan. 1, 1930, all production, sale, or of white lead in any form is prohibited the whole of Russia.

Chicago, 1,000 miles from the sea, is sec only to New York in imports. The cust duties collected there in 1924 amounted $15,536,966.

The Transvaal, the world's greatest g field, eclipsed all former records in 1924—p ducing 9,597,634 fine ounces having a coi value of about $198,000,000.

SWISS LARGE USERS OF ELECTRICITY

SWITZERLAND, with its 360 electric-p er stations, is producing in excess of 3,0 000,000 kilowatt-hours annually. The gre portion of this energy is used for light, h and power purposes—the remainder be drawn upon by the electrochemical and me lurgical industries and by the railroads. S tistics show that 95 per cent. of all localities Switzerland are furnished with electricity that 90 per cent. of the homes are supp with electric light. In fact, it is estima that only 2 per cent. of the total Swiss po lation does not enjoy the convenience of el tricity. All large power plants in Switzerl are interconnected, thus making for the gre est possible utilization of their output.